Features of Establishing Oak Plantations in Azerbaijan

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Abstract

In Azerbaijan, oak forests play an essential role in preserving biodiversity, protecting soil and water resources, and ensuring the environmental sustainability of forest ecosystems. This article examines the main aspects of establishing oak plantations in Azerbaijan, the bio-ecological characteristics of oak species, reforestation methods, and agronomic measures for the management of these plantations. Particular attention is paid to the conservation and restoration of populations of the chestnut-leaved oak (*Quercus castaneifolia*) and the Araxian oak (*Quercus araxina*), both of which are listed in Azerbaijan's 'Red Book'. This analysis examines seed sowing, seedling planting and combined methods of establishing oak plantations, as well as the 'hill-drop drilling' and 'square-cluster planting' methods. The issue also examines matters relating to the supply and storage of seeds, soil preparation, determining planting density, protecting planting areas and caring for young plants. The advantages of direct sowing are highlighted in terms of promoting the development of the oak's taproot system and increasing its drought tolerance. Experience of establishing oak plantations in Azerbaijan shows that, for successful afforestation, it is necessary to take into account the soil and climatic conditions of the area in question, the topography of the terrain, and the potential for natural forest regeneration. The findings of the study highlight the importance of scientifically sound afforestation methods for the conservation of native oak species, the restoration of degraded forest areas, and the sustainable development of forest ecosystems.

Keywords: oak forests, oak plantations, Chestnut-leaved oak, Araxian oak, afforestation, seed sowing, afforestation methods, agronomic management, biodiversity conservation

1. Introduction

1.1. Distribution, bioecology and uses of the oak

There are nine known species of oak in Azerbaijan: Chestnut-leaved oak (*Quercus castaneifolia*), Caucasian oak (*Quercus macranthera*), Araxian oak (*Quercus araxina*), English oak (*Quercus longipes*), Georgian oak (*Quercus iberica*), Silver oak (*Quercus hypochrysa*), Downy oak (*Quercus crispata stev.*), and other varieties. Tree species such as Holm oak (*Quercus ilex*), Cork oak (*Quercus suber*), and the западный дуб have been introduced to various regions and are now being cultivated there (Əsədov et al., 2008; Safarov & Olisaev, 1991).

Oak forests in Azerbaijan are mainly found in foothill and mountainous areas (at altitudes of up to 2,000 metres) and account for a significant proportion of the country's forest cover – up to 23%. Georgian, chestnut-leaved, English, Oriental and Araxian oaks are widespread, forming dense stands, particularly on the southern slopes of the Talish Mountains and the Greater Caucasus. These forests are also of great ecological and economic importance. Of these species, the chestnut-leaved oak and the Araxian oak are

listed in Azerbaijan's 'Red Book'. The following section will now examine some of the characteristics of these types (Anuchin, 1982; Bandin, 1954).

1. The chestnut-leaved oak (*Quercus castaneifolia, C. A. Mey*) is a rare species of tree native to Azerbaijan, found predominantly in the Lankaran natural province (in the Talish Mountains). The chestnut-leaved oak is a tree that thrives in warm, sunny conditions. It is one of the relict plants of the Tertiary period and a representative of the Hircanian flora, characteristic of the ancient Arctic Tertiary epoch (the Turganian period) (Mamedova & Mamedova, 2019; Yakhyaev, 2023). (Figure. 1)



Figure 1. *Beech forest.*

It got its name because its leaves look very much like chestnut leaves. This majestic tree can reach a height of 30-35 metres, and its trunk can measure 1.0-1.5 metres in diameter. (Alekseev, 1989; Maleev, 1935; Seifullaev, 2017). The leaves are usually 10-15 cm long, lanceolate, oblong-elliptic or oblong-lanceolate, with a wedge-shaped, rounded or slightly heart-shaped base; the apex ends in a sharp triangular point, and the margin is coarsely toothed. (Figure. 2)



Figure 2. *A young chestnut-leaved oak tree.*

Fruits: The nuts are large, 2.5-3.5 cm long. Flowering takes place in April–May, whilst the nuts ripen in September–October. 1,000 seeds weigh 7 kg (Figure 3). It is a long-lived plant; it can live for 400-500 years, and sometimes even longer.



Figure 3. *Oak acorns.*

As oak is a hard and valuable timber, it is used in shipbuilding, joinery, furniture-making, and cooperage. Nuts are also a main source of food for animals. Ancient and giant specimens of this species can be found in the Hirkan National Park. It grows in Iran (Gilan, Mazandaran), in the Caucasus, including the Talysh Mountains in Azerbaijan (from the plains up to an altitude of 2,000 metres above sea level) (Badalov, 1969). Amongst oak species, it grows faster and produces a bountiful seed crop every year. Natural regeneration from seed occurs successfully in moist forest ecosystems. It adapts quickly to local conditions, so growing it in a variety of climatic and soil conditions presents no difficulties.

2. Araxian oak (*Quercus araxina A.Grossh.*). Araxian oak is a valuable timber species belonging to the genus Quercus in the family Fagaceae. A tree species characterised by its resilience and endemic features, it forms an integral part of forest ecosystems and is found predominantly in the Okchuchay area, the Aras River basin, and the Caucasus region. It is listed in the 'Red Book of Azerbaijan'.

As a species of oak, it is a deciduous tree with high environmental resilience. This is a tree that can grow up to 20 metres tall. The leaves are 6-8 cm long and 2-7 cm wide, oblong-ovate or elliptical. Bright green on top, pale green underneath, with sparse pubescence. The edges are serrated, resembling a blunt cut. It flowers in March–April, and the nuts ripen in August–September. The fruit is small, with a short stalk; its calyx, which is cap-shaped, is covered with felt-like hairs and densely scaly. (Amirov, 1997; Maleev, 1935).

This herb grows naturally in northern Iran and the Caucasus. In Azerbaijan, this plant grows in forests at altitudes of 500-1,100 metres in the Zengilan and Kubadli districts in the south of the Lesser Caucasus. In some cases, it also forms monocultural forests. Resistant to high temperatures and frost. It contributes to the formation of swamp forests in extremely arid conditions. It is of exceptional importance for afforestation on dry mountain slopes. A drought-tolerant species of tree that does not require any special care. It can be found in the landscaping of botanical gardens and in the Aran region.

A significant portion of the valuable Araz oak forest, situated in the Okchuchay Nature Reserve within the occupied Zengilan district, was subjected to environmental terrorism during the occupation. All the trees in the forest were felled and destroyed. In conclusion, it should be noted that the main species of oak found in Azerbaijan (Chestnut-leaved oak, Caucasian oak, Araxian oak, English oak, Georgian oak) are considered endemic to the Caucasus; that is, these trees grow naturally only in the Caucasus and neighbouring regions (Turkey, Iran). Two species – Chestnut-leaved oak and the Araxian oak – are already listed in Azerbaijan's 'Red Book', and it is now vital to take special measures to protect them, as they are important components of Azerbaijan's tree flora. Therefore, the establishment of plantations of these tree species is regarded as the most effective management measure aimed at restoring and expanding oak stands and natural forests, protecting the forest ecosystem, ensuring its sustainable development, and so on (Əsədov et al., 2008).

2. Results and Discussion

2.1. Experience of establishing oak plantations in Azerbaijan

Although the establishment of oak plantations in our country became more widespread from the second half of the last century, for a long time these plantations failed to produce the desired results. The reasons for this included, in particular, the difficulty of ensuring timely weeding in forest plantations, as well as – in the case of direct seeding – the lack of soil preparation, the difficulty of protecting the plants from adverse natural phenomena, and the poor adaptation of the species. (Figure. 4)



Figure 4. *Cultivation of Chestnut-leaved oak in the Ismayilli District.*

Oak forests are currently being restored in Azerbaijan as part of government programmes. For example, of the 45.7 tonnes of seeds collected for afforestation in 2021, 38.3 tonnes were acorns. Particular attention is paid to the artificial restoration of oak as one of the most valuable timber species, especially in reclaimed areas and in tugai forests (the Kura–Araks Lowlands), using methods designed to ensure the successful establishment of oak plantations (Figure 5).



Figure 5. *Chestnut-leaved oak.*

Types of oak plantations:

Continuous and Partial oak plantations is practised on arid land with unirrigated soils in foothill, lower and mid-mountain regions.

Continuous oak planting – On former arable land, clear-cut areas and glades, plots cleared of crops, and on mountain slopes, sampling is carried out using a 2×2-metre grid, employing one of two methods:

either furrows are ploughed using a tractor, or 1×1-metre plots are marked out by hand (Anuchin, 1982; Mammadov & Asadov, 2010).

With this type of planting, the sowing or planting sites are spaced out relatively evenly to ensure that the main (cultivated) species dominate the future stand. Continuous forest plantations are established using either full or partial soil preparation. Although the use of machinery to cross-cut furrows, where possible, helps to reduce manual labour and lower the costs of sowing crops, the presence of stump remnants in these areas, the steepness of the slopes, the lack of specialised machinery and the difficulty in operating it, and, finally, the fact that manual soil preparation is considered the best approach for preserving the soil and vegetation cover on these slopes.

Partial planting is carried out in cases where natural forest regeneration is taking place on the plantation site or is expected to occur. Consequently, the establishment of partial afforestation involves the use of a combined afforestation method that *combines natural and artificial forest regeneration*. Tree plantings established on reforestation sites, taking into account existing natural regeneration, will form mixed stands in the future. As a general rule, partial reforestation is carried out on felled areas where natural regeneration of the main tree species is taking place.

Partial planting, unlike continuous planting, is always carried out on partially tilled soil. At this stage, only the part of the field where economically valuable tree species are to be planted is ploughed. Seeding is usually carried out in plots measuring 1×1 metre (2,000-2,500 plots per hectare).

In forests established as continuous plantations, the forest stand develops without any natural regeneration taking place. Compared with partial forest plantations, continuous forest plantations vary considerably in terms of tree species composition, density, soil preparation methods, planting patterns and the mixing of tree species (Методический кабинет Гидрометцентра России. (n.d.).

In the case of *partial planting*, the land is prepared, and monocultures are established, whilst mixed forests sometimes develop as a result of natural regeneration. The advantage is that the crop is grown in a forest environment, which prevents the formation of natural grass cover and helps to reduce the amount of planting material required, as well as labour and resource costs.

2.2. Key aspects of establishing oak plantations

There are three ways to establish oak plantations: *by planting saplings, by sowing seeds, and by a combined method*.

Sowing method (direct sowing method) – Oak acorns (seeds) are sown directly onto the prepared plots. This method allows the oak's vertical root system (the taproot) to develop unhindered, which makes the tree more drought-resistant in the future (Figure 6).



Figure 6. *Planting of chestnut-leaved oak.*

Planting method (planting seedlings) – One- and two-year-old oak seedlings, grown in nurseries, are planted in reforestation areas. This method reduces the risk of the seeds being eaten by rodents and helps the plants get through the initial growth stage more quickly (Mamedov, 2004).

A combined method – Both planting and sowing take place in the same forest area. Furthermore, it is used to create protective strips featuring oak trees. On oak plantations, the sowing method should generally be used. This is because oak acorns develop powerful taproots, which penetrate to a depth of up to one metre in their very first year. When transplanted into the field, the seedling loses most of its root system, which has a very negative effect on its condition. The newly formed roots of cuttings penetrate the soil more slowly than the roots of newly emerged seedlings grown from seed. Only when soil moisture is at an optimal level can sowing and planting cuttings be equally successful.

The *sowing method* used in the establishment of oak plantations comprises the following *stages:*

Seed preparation: Oak acorns ripen in late October–early November. However, for use in afforestation schemes and orchards, it is necessary to wait until the seeds are fully ripe. This process can continue until as late as 15 November. Acorns are gathered by hand once the seeds have ripened and fallen to the ground. To check the quality of the seeds, they are placed in water; empty husks that float to the surface are discarded, whilst those that sink to the bottom are considered suitable for sowing. The harvested seeds should be sorted, removing any that are diseased or damaged.

In the mountainous and foothill regions of the Lesser Caucasus, the Greater Caucasus and the Talysh Mountains, it is more advisable to leave oak acorns in the forest until spring arrives. The area of woodland set aside for seed collection must first be cleared of small shrubs and undergrowth. However, when clearing the area, you must not disturb the dead ground cover or the leaves that have fallen to the ground. A layer of seeds 5-6 cm thick is spread over the leaves, followed by a layer of leaves 15-20 cm thick. If frosts are expected or likely, the thickness of the top layer of leaves is increased to 30 cm (Mustafayev, 2012; Safarov, 1967).

In the Aran regions, it is recommended to store acorns in cellars. Small batches of seeds for spring sowing can also be stored in running water. Oak acorns can be stored for up to two years in ice cellars, freezer cellars and deep trenches.

Soil preparation: Soil preparation is carried out taking into account the soil and climatic conditions of the area where sowing is to take place, its topography, altitude above sea level, the orientation and gradient of the slopes, as well as the feasibility of using machinery.

When carrying out continuous sowing on mountainous terrain – on old scree slopes, in clearings and forest aisles, on land freed up after the harvest of agricultural crops, and on exposed mountain slopes:

– Where mechanical tillage is possible, ploughing to a depth of 60–80 cm promotes good root system development. Once the field has been ploughed, furrows are dug at two-metre intervals for sowing the seeds. On mountain slopes, in order to reduce costs, prevent the complete destruction of the site's soil cover and improve its resistance to erosion, the land is often ploughed not across the slope but in furrows (50 per hectare);

– In areas where machinery cannot be used, the field is tilled in 1×1-metre plots arranged in a 2×2-metre grid, amounting to 2,500 squares per hectare.

In afforestation, partial planting is carried out in cases where natural regeneration is observed or expected. In such cases, 1,200-1,500 plots of various shapes and sizes are prepared in the open areas of the site. Establishing protective tree belts *on flat terrain*: *the combined method, the row-nest method, and the square-nest* method are used.

Seed sowing: sowing is carried out using the row-nest and square-nest methods.

With the *'row-nest' method*, seeds are sown into holes made along the sowing rows, with 3-5 seeds in each hole, and the resulting plants form *bio-groups*. When using the *'square-nest' method*, holes are made in

rows of seeds at intervals corresponding to the planting pattern; in plots measuring 1×1 m, squares are formed (creating a 'square' pattern), then four holes are placed within each of these squares, and 3-5 seeds are sown into each hole. The resulting plants, from both the holes and the squares, form a *combined bio-group* (Shevchenko & Tsilyurik, 1986).

Defence: Artificially restored areas must be fenced off to protect the young saplings from damage caused by wild animals and livestock. Erecting barriers, where possible in mountainous areas, 1.0 metre wide. This can be achieved by digging trenches 1.5 metres deep, piling up the excavated earth to form berms, and using local materials (such as poles, stakes and blackberry bushes obtained from pruning, etc.) to reinforce the tops of these berms. As this type of fencing is both cheaper and more effective, it is considered suitable for all arable land in mountainous areas.

2.3. The main sowing methods, mixing patterns and planting densities used in oak plantations

In mountainous areas:

– With *continuous planting* in furrows using the *'row-nest' method* (with a spacing of 2×1 m), 50 furrows are laid out per hectare, spaced 2 metres apart.

– The planting holes are prepared in furrows at intervals of 1 metre, and 3-5 acorns are sown in each hole. Given that the average weight of each seed (of the sessile oak) is 7 grams, the sowing rate per hectare can range from 105 to 175 kg, whilst the number of one-year-old seedlings can vary from 15,000 to 25,000.

In *continuous sowing* using the *'square-nest' method*, with planting spots arranged according to a 2×2 m scheme, 2,500 plots measuring 1×1 m are prepared per hectare. Four holes are made in each of these plots (squares) – one in each corner – and between three and five seeds are sown into each hole. This results in 10,000 sowing points per hectare (Yakhyaev, 2007; Yakhyaev et al., 2011).

Given that the average weight of a seed (of the sessile oak) is 7 grams, the seed yield per hectare can range from 210 to 350 kg, whilst the number of one-year-old seedlings can vary from 30,000 to 50,000. In reforestation under natural regeneration conditions, sowing is carried out in part on plots using the 'square-nest' method (on a 2×2 metre grid), with between 1,200 and 1,500 plots, each measuring 1 square metre, being prepared per hectare. Four holes are prepared in each plot (square), with 3-5 seeds sown into each. This results in 4,800-6,000 sowing points per hectare. With this sowing method, the number of radish seedlings per hectare can range from 14,400 to 30,000, and seed consumption from 100 to 240 kg.

The following methods are used when establishing protective tree belts on *flat terrain*:

From 1950–1951, work began in Azerbaijan under the leadership of Ibrahim Safarov to establish shelterbelts. When planting trees in the shelterbelts, preference was given to oak species (Chestnut-leaved oak, English oak). Oak seeds were sown using the '*square nest' method*, with the planting holes arranged in blocks across the plots. This method was mainly used in arid conditions.

In irrigated conditions, this arrangement of holes makes it difficult to water crops. With this in mind, it was proposed that acorns from the oak – used as the main tree species – be planted using the '*6-hole' method*, with three holes on either side of the irrigation furrow. When watered, these holes are well supplied with moisture. The optimum depth for the watering furrows has been found to be 35–40 cm, whilst the acorns are sown at a depth of 8–10 cm. In all cases, the planting area must be cleared of weeds, stones and shrubs (Yakhyaev et al., 2017).

The methods described above involve the establishment of monoculture plantations of the genus Quercus, and it appears that the number of sowing sites per hectare ranges from 4,800 to 10,000, whilst the number of seedlings produced varies from 14,000 to 50,000. This is a very high density and, according to the planting density scale, it falls into the category of the densest plantations.

The main purpose of creating such dense stands is to intensify competition for limited resources – light, water, nutrients and space – amongst individuals of the same species. This process stimulates natural selection, leading either to the survival of the fittest or to the displacement of species.

As a result, after 3–5 years, instead of 12–20, approximately 2–4 of the strongest and healthiest oak seedlings remain in each plot. The average annual height growth of the seedlings reaches 35–40 cm.

The results presented were obtained from sweet chestnut plantations established using the 'square nest' method at the Jalilabad Forestry Enterprise in the early 2000s. On these plantations, grown in arid conditions, the average height of the seedlings reached almost 2.0 metres after five years, whilst the actual survival rate exceeded 80%.

2. 4. Agronomic management of oak plantations

Agricultural practices aimed at improving the growing conditions for tree and shrub species cultivated in forestry; agronomic measures aimed at creating more favourable conditions and ensuring optimal conditions include a range of activities, such as regular soil cultivation, soil loosening and weed control. In pure oak stands, the main aim of these operations is to ensure that the plot remains weed-free through systematic soil cultivation or inter-row cultivation, thereby reducing competition for light and water.

In oak plantations with mixed stands, the primary management objective is, first and foremost, to remove undergrowth through timely thinning, as well as to clear the site of unwanted oak seedlings that hinder the successful growth of higher-quality trees, in order to prevent the oak stands from being displaced by faster-growing species at a young age. In arid, desert conditions, whether planting in holes or in furrows, two 3–5-year-old oak saplings should be left in each hole, and the rest should be removed (Yakhyaev, 2004; Yakhyaev, 2007).

3. Conclusion

This article provides a brief overview of oak trees and oak forests, which form part of Azerbaijan's forest resources. A review of the literature has shown that nine species of oak grow in our forests; of these, the chestnut-leaved oak and the Arax oak are threatened with extinction; consequently, these oak species have been included in the Republic's 'Red List'. In light of this, we investigated issues relating to the restoration and sustainable development of these oak species, including the establishment of oak plantations in previously studied areas.

It has been established that oak plantations are created in two ways:

In mountainous areas

– *For continuous planting*, when sowing in furrows using *the 'row-nest' method* (in a 2×1 m pattern), 50 furrows are laid out per hectare at 2-metre intervals. Nests are prepared in the furrows at one-metre intervals, with 3–5 acorn seeds sown into each nest. Given that the average weight of a single seed (for the sessile oak) is 7 grams, the sowing rate per hectare is 105–175 kg, and the number of one-year-old seedlings can vary from 15,000 to 25,000.

– During *continuous sowing* in plots (following a 2×2 m grid) using the '*square nest' method*, 2,500 plots measuring 1×1 metre are prepared per hectare. Four planting holes are formed in each of these plots (squares) – one in each corner – and 3–5 seeds are sown into each hole. In this way, 10,000 sowing points are created per hectare.

The following methods are used when establishing protective tree belts on *flat terrain*:

From 1950–1951, work began on the creation of shelterbelts in Azerbaijan under the leadership of Ibrahim Safarov. When establishing shelterbelts, preference was given to oak species (chestnut-leaved oak, English oak). Oak seeds were sown using the '*square nest' method*, with the planting holes arranged in blocks across the plots. This method was mainly used in arid conditions.

Author's contribution

The sole author is responsible for conceptualizing, collecting, and analyzing data, and writing and editing the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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