

Hazelnut Culture in Azerbaijan

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ABSTRACT

Hazelnut (*Corylus avellana* L.) cultivation is of significant economic importance to Azerbaijan, ranking the country as the fourth-largest global producer, following Türkiye, Italy and USA. This perennial plant, deeply placed in the cultural and agricultural history of the Greater Caucasus region, is predominantly cultivated in the northern regions of Azerbaijan, specifically in the Sheki-Zagatala and Guba-Khachmaz economic zones. The industry has evolved over centuries, with notable advancements during the Soviet era, including the establishment of the first hazelnut processing factories and state farms. Despite the high demand, domestic consumption remains limited, prompting ongoing efforts to expand production through modern agricultural practices and the preservation of local hazelnut cultivars. This paper explores the historical context, current cultivars, orchard management, and the challenges posed by pathogens and pests affecting hazelnut production in Azerbaijan.

Keywords: Hazelnut, Azerbaijan, Cultivars, Orchard Management, Pathogens, Pests, *Glis glis*

Azərbaycan'da Fındık Yetiştiriciliği

ÖZ

Fındık (*Corylus avellana* L.) yetiştiriciliği, Azərbaycan için büyük ekonomik öneme sahiptir ve ülkeyi Türkiye, İtalya ve ABD'nin ardından dünyanın en büyük dördüncü üreticisi konumuna getirmiştir. Büyük Kafkasya bölgesinin kültürel ve tarımsal tarihinde önemli bir yeri olan bu çok yıllık bitki, ağırlıklı olarak Azərbaycan'ın kuzey bölgelerinde, özellikle Şeki-Zagatala ve Guba-Haçmaz ekonomik bölgelerinde yetiştirilmektedir. Fındık sektörü yüzyıllar içinde gelişmiş olup, Sovyetler Birliği döneminde ilk fındık işleme fabrikalarının ve devlet çiftliklerinin kurulması gibi önemli ilerlemeler kaydedilmiştir. Yüksek talebe rağmen, yurtiçi tüketim sınırlı kalmaktadır ve bu durum, yerli fındık çeşitlerinin korunması ve modern tarım uygulamalarıyla üretimin artırılması yönünde devam eden çabalara yol açmaktadır. Bu makalede Azərbaycan'da fındık üretiminin tarihsel arka planı, mevcut çeşitleri, bahçe yönetimi ile hastalık ve zararlıların oluşturduğu zorluklar ele alınmaktadır.

Anahtar Kelimeler: Fındık, Azərbaycan, Çeşitler, Bahçe Yönetimi, Patojenler, Zararlılar, *Glis glis*

INTRODUCTION

The hazelnut (*Corylus avellana* L.), a perennial deciduous plant belonging to the Betulaceae family, holds significant economic importance in Azerbaijan, particularly due to its high export potential. Globally, Azerbaijan is the fourth-largest producer of hazelnuts, following Türkiye, Italy and USA [1]. According to the Azerbaijan State Customs Committee's monthly report on the State of Foreign Trade, Azerbaijan exported 8,425 tons of hazelnuts valued at \$51,900,000 from January to June 2024.

The hazelnut has been cultivated to the Greater Caucasus region since ancient times and has been utilized by the local population for centuries. Historical accounts and writings of ancient Greek and Roman scholars document the use of hazelnuts in

ancient times including in the Greater Caucasus, highlighting its longstanding presence and cultural significance in the region [2].

Hazelnut cultivation in Azerbaijan is predominantly concentrated in the northern regions of the country. Notably, the Sheki-Zagatala (Sheki, Zagatala, Balakan, Oghuz, Gakh, and Gabala) and Guba-Khachmaz (Shabran, Khachmaz, Guba, Gusar, and Siyazan) economic regions represent the areas with the highest production and cultivated land for hazelnuts. The Sheki-Zagatala economic region, in particular, stands as the principal center for hazelnut production, possessing a rich tradition of cultivation that dates back centuries.

The development of hazelnut cultivation in Sheki-Zagatala had significant attention following the establishment of the Soviet Union [3]. In 1929, the

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first hazelnut processing factory in both Azerbaijan and the USSR was set up in the Zagatala district. This was followed by the establishment of the first hazelnut-growing sovkhos (state-owned collective agriculture; farm association) in 1932, also located in Zagatala. By the mid-19th century, hazelnut cultivation had become a critical component of the regional economy.

European hazel (*Corylus avellana* L.) is widely distributed across the Republic of Azerbaijan. Despite the high demand for hazelnuts in Azerbaijan, only 15-20% of the population get income with this nut tree [4].

Significant increases in hazelnut production in the Republic of Azerbaijan were observed during the years 2017, 2018, and 2021. In 2017, total hazelnut production increased by 32.8% compared to the previous year. This increase was attributed to the substantial rise in market prices for hazelnuts in the preceding year and the implementation of Presidential Order № 1081, dated March 2, 2015, titled "On additional measures related to the strengthening of state support for the development of agriculture" [2].

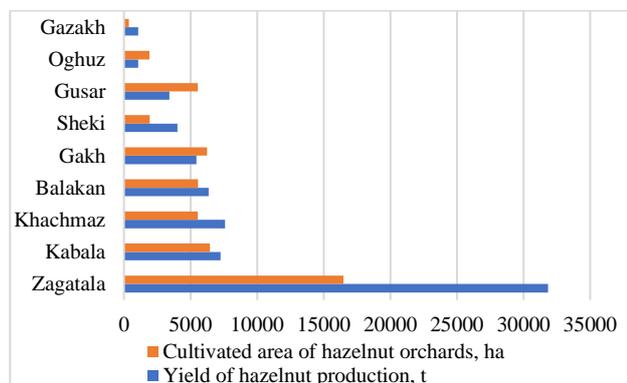


Figure 1. Cultivated area and hazelnut production across regions in Azerbaijan in 2022

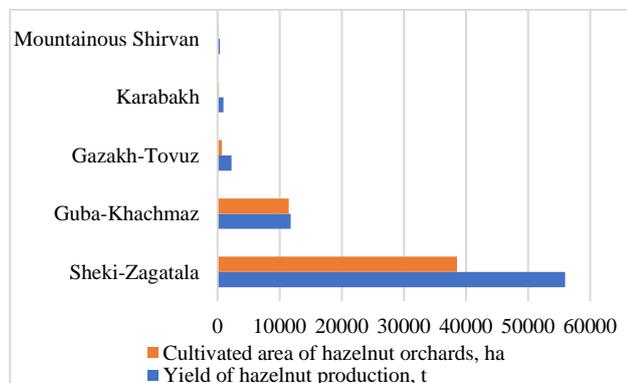


Figure 2. Comparison of cultivated area and hazelnut yield across economic regions of Azerbaijan for 2022

Cultivars

Currently, the most widespread hazelnut cultivar in Azerbaijan is Ata-baba (80-90%) [5]. However, the prominent agricultural scientist of Azerbaijan, Ahmad Rajabli, in his book 'Hazelnuts, Walnuts, and Chestnuts' published in 1932, mentions four main cultivars of hazelnuts common in Azerbaijan:

•*Fast-ripening Zagatala hazelnut*: This cultivar is vigorous, well-developed as a shrub (ocak), of medium height, and has medium yields. The nuts are medium-sized, thin-skinned, and dull red in color. The kernel is tasty, and the nut shell is thick. It ripens in first half of August and is grown in Zagatala and eastern regions.

•*Late-ripening Zagatala hazelnut*: This is one of the most valuable and durable local cultivars. The shrub is well-maintained and productive. The nuts are large, with a medium-thick red peel. The husk is longer than the nuts. The thickness and width of the nut are 17 mm, and the length is 19 mm. Its testa is thin, and the kernel is oily and tasty.

•*Qosa findig*: This cultivar is found in the Zagatala and Gakh regions. It is productive, and the shrub is of medium height with small leaves. It is an early ripening cultivar. The husk covers up to half of the nut, and when the nut is ripe, it easily separates from the husk and falls down. The kernel is delicious.

•*Calag findig*: This cultivar is found in the Balakan and Sheki regions. It is not productive. The nuts are quite large compared to other cultivars, with a thickness of 22 mm, width of 24 mm, and length of 25 mm. The shell is yellowish and thin. The nut weevil (*Curculio nucum* L.) causes significant damage to this cultivar. Many of the nuts are not fully developed, and the kernels are tasteless and low in fat.

Since 2008, the hazelnut gene pool has been systematically collected and maintained at the Sheki and Oguz Research Bases of the Institute of Genetic Resources, Azerbaijan National Academy of Sciences [6].

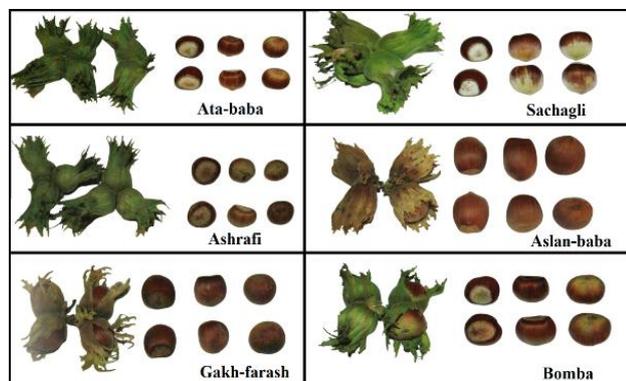
Hazelnut cultivars grown in Azerbaijan can be divided into three groups [4]:

1. Local, heritage cultivars,
2. Introduced cultivars,
3. Cultivars obtained as a result of selection,

The cultivars included in the first group are local cultivars that have been cultivated since ancient times. These include: 'Ata-baba', 'Yagli', 'Ashrafi', 'Ganja', and 'Bomba'.

•*Ata-baba cultivar*: This is the oldest cultivar cultivated in the Sheki-Zagatala region. The plants are medium-sized (5-8 m), with a round, densely leafy canopy, and productive. A single ocak yields 16-20 kg (sometimes more). The nut is medium-

sized, round, and ripens in September. The nut shell is thick, and the kernel yield is 53%. The kernel is tasty and oily. It is propagated by separating the root suckers from the plant [4, 5].



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Figure 3. Some of the hazelnut cultivars grown in Azerbaijan

•*Yagli cultivar*: The cultivar is prevalent in the Balakan region. It exhibits high productivity, with potential yields reaching up to 32 kg per ocaq.

It has hard wood, and the husk is short, not fully enclosing the nut. The nuts are elongated and round, characterized by a very hard shell with a striking red hue. On average, there are 360 nuts per kilogram, and the kernel's fat content ranges from 50% to 69% [4, 7, 8].

•*Ashrafi cultivar*: It is extensively cultivated in the vicinity of Vardanli village in the Gakh district. This cultivar is notably short but highly productive. The nuts are round, with a very thin, easily breakable shell. They ripen in mid-August. The kernel fills the nut completely, presenting a smooth surface. The kernel yield is 62%, and it is known for its pleasant taste and high fat content. There are approximately 730 nuts per kilogram [4, 7].

•*Ganja cultivar*: The cultivar exhibits vigorous shrub growth with a slightly drooping habit. The husk is approximately twice the length of the nut. The nut itself is characterized by a flat tuberous shape. The shell thickness ranges from 1.0 to 1.25 mm, exhibiting a bright cinnamon color, occasionally marked with gray lines. The kernel does not completely fill the interior of the shell, and high fat content, comprising 60% of its composition. The kernels are consumable in their raw state, with a kernel yield of 54% [4, 7].

•*Bomba cultivar*: The cultivar is a traditional selection from Azerbaijan, is a medium-sized shrub reaching heights of 6-8 meters with a sparse structure. It exhibits minimal damage from the nut weevil. Fruit

production begins in the 5th year, with an average yield of 9 kg per shrub. The nuts ripen in early September. They are large, weighing approximately 2.8 grams, and has a round and ribbed morphology. The shell is of medium thickness and light in color. The kernel is enveloped in a brown testa and has a yield of 50.5% [4].

Other local heritage cultivars include 'Unglu', 'Sivri Mazi', 'Gakh 29', and 'Oguz 5'.

The introduced hazelnut cultivars include 'Barcelona', 'Tonda Gentile Romana', 'Tonda di Giffoni', 'Ennis', 'Negret', 'Rimsky', 'Ag Lombard', 'Girmizi Lombard', 'Abkhaz Orta', 'Kurdayavchik', 'Cherkaz-11', 'Futkurami', 'Khacapura', among others.

The cultivars classified in the third group comprise those developed through selection at the Azerbaijan Scientific Research Institute of Fruit and Tea Growing. Examples of these cultivars include 'Azeri', 'Nasimi', 'Arzu', 'Barli', 'Ghalib', 'Aslan-baba', 'Topgara', 'Gobekli', 'Parzivan Zarifi', 'Tala', 'Ata-ulla', 'Firavan', 'Sachagli', 'Zagatala', 'Elbari', 'Gakh-farash', and 'Gizil findig'.

Orchards

Orchards can be classified into three categories: household orchards, private orchards managed by smallholders, and commercial orchards. In rural areas, orchards are frequently part of family legacies. Many growers, having migrated to urban centers, often allow these orchards to grow unattended, utilizing the yield primarily for personal consumption or to supplement household income. For market-oriented smallholders, hazelnut orchards typically serve as a secondary income source [9].

In the region, numerous hazelnut orchards are established using traditional methods, adhering to spacing schemes of 6×7 m, 7×7 m, and 7×8 m. Variations in planting density, either more compact or sparser arrangements, can also be observed. These orchards, along with those planted by local inhabitants, often exhibit a stem planting configuration resembling the circular "Ocak" system utilized in Türkiye, locally referred to as "Topa." The "Ocak" system involves planting stems in a circular arrangement with a diameter of 1 meter [10]. However, in traditional Azerbaijani hazelnut orchards and those established by local populations, this diameter is notably smaller.

A significant number of hazelnut orchards in Azerbaijan suffer from neglect, resulting in excessive production of suckers by the hazelnut plants. Failure to adequately sucker control leads to an excessive proliferation of stems in the hazelnut plant, as

presented in Figure 4. This issue arises because hazelnut cultivation is not the primary income source for the majority of growers. Nevertheless, the recent surge in interest in hazelnut cultivation has facilitated the establishment of new orchards employing contemporary agricultural methods and has prompted the redevelopment of certain traditional hazelnut orchards.



Figure 4. Sucker overgrowth due to orchard neglect

During the hazelnut harvest, the nuts are typically collected by manually shaking the trunks, allowing the crop to fall to the ground for collection. In cultivars that mature early, the nuts are sometimes detached directly from the shrub. In extensive orchards, the harvest is usually carried out by workers. The harvested hazelnuts are then packed into bags and transported from the orchard. Post-harvest, the nuts are dehusked either manually or mechanically. Mechanically dehusked nuts generally command a higher market price compared to those dehusked by hand. The dehusked nuts are then either sold to local buyers, who may subsequently sell them to hazelnut processing factories, or farmers may directly sell the dehusked product to these factories.

Historically in the past, in Zagatala, male domestic water buffaloes were utilized to separate the harvested hazelnuts from their husks. The harvested crop was piled in a designated area, where the buffaloes, using their hooves, effectively dislodged the nuts from the husks. Following this process, workers would gather the separated nuts into containers for further processing [11].

The Main Pathogens and Pests of Hazelnuts in Azerbaijan

•Pathogens

Powdery mildew, caused by *Phyllactinia guttata* (Wallr. Fr.) Lev. and *Erysiphe Corylacearum* U.Braun & S.Takam., is a prevalent pathogen in the northern hazelnut-growing regions of Azerbaijan. This disease manifests as a white, cobweb-like or powdery coating on the leaves of hazelnut plants, which gradually disappears from the underside of the leaf blades. Subsequently, yellow, pointed fruiting bodies emerge on the underside of the leaves, eventually turning black. The infected foliage prematurely yellows and abscises. The pathogens overwinter in infected plant debris, primarily in the form of mycelium. Primary infection and subsequent dissemination of the fungus occur through ascospores and conidia. This disease is particularly common in the northwestern regions of the country. Over a three-year study conducted in Azerbaijan, it was observed that the Ata-baba cultivar was the most susceptible to this disease, with the local climatic conditions favoring its development [12].

Bacterial blight, caused by *Xanthomonas campestris* pv. *corylina* (Miller et al.) Dye, was initially identified on *Corylus maxima* in Oregon, USA. Subsequently, the pathogen has been reported in several other countries, including Chile, France, Italy, England, Türkiye, and Iran [13]. This disease is also present in hazelnut orchards in Azerbaijan. The long-distance dissemination of this bacterial pathogen is primarily facilitated by water splashes, wind-driven rain, aerosol vectors such as humans, mites, and insects, as well as the importation of infected fruits and planting materials [14].

Apple Mosaic Virus (ApMV) is among the pathogens present in hazelnut orchards in Azerbaijan. ApMV induces various symptoms on hazelnut leaves, including mosaic patterns, interveinal banding, chlorotic ring spots, and an oak leaf pattern. Mild strains of the virus typically cause chlorotic spots, while more virulent strains can lead to extensive chlorosis or even the entire leaf turning golden yellow [15]. The severity of virus infection can vary depending on the cultivar [16]. The primary method of long-distance transmission of ApMV is through grafting and vegetative propagation materials. The virus can also be transmitted to certain test plants via mechanical inoculation. While ApMV is known to be lethal to a broad range of rootstocks, its natural vector remains unidentified. There is a possibility that ApMV is transmitted by an as-yet-undiscovered slow-moving arthropod vector or through root fusion, though the vector hypothesis appears less likely [17].

Examples of other common pathogens in hazelnut orchards include *Armillaria* root rot (*Armillaria mellea*), bacterial canker (*Pseudomonas avellanae*), and moniliosis (*Monilia Coryli*).

•Pests

The brown marmorated stink bug (*Halyomorpha halys* Stål) is a significant pest affecting hazelnut cultivation in Azerbaijan. First detected in the country in 2017 by researchers from the Institute of Zoology, the pest was discovered under a collapsed building in Baku and in the village of Muganli in the Balakan district. The pest's host range includes over 170 plant species [18], many of which are also found in Azerbaijan, exacerbating the threat. The brown marmorated stink bug primarily disperses by flight during spring and summer, and through packaging and transport vehicles seeking shelter during autumn and winter. This pest poses a substantial threat to Azerbaijani fruit production, particularly to hazelnut orchards. In response to this risk, the Cabinet of Ministers of the Republic of Azerbaijan approved the "Plan of Measures for Plant Protection Against the Brown Marmorated Stink Bug" on December 30, 2022, under Order No. 819. This plan outlines urgent actions aimed at curbing the spread of the pest, including public awareness campaigns in various regions to inform and educate the population [19].

Hazelnut aphids, particularly the hazel aphid (*Myzocallis coryli*) and the large hazel aphid (*Corylobium avellanae*), are prevalent pests of hazelnut plants in Azerbaijan. The presence of both aphid species can facilitate the development of powdery mildew on hazelnut leaves. The females of *M.coryli* oviposit on the trunk and primary branches of hazel trees, with the eggs overwintering in bark crevices or bud scales of infected stems aged 2-3 years. Nymphs emerge from these eggs in March, initially feeding on buds before migrating to the underside of newly expanded leaves. After undergoing four molts, they reach adulthood. Adult female aphids of *M.coryli* are capable of producing numerous parthenogenetic generations throughout the summer. These pests feed on the leaves and husks and developing fruits of the hazelnut tree. The population density of *M.coryli* typically peaks in May and June under favorable environmental conditions, but declines later due to high temperatures and increased predation [20, 21].

Corylobium avellanae, commonly known as the hazelnut aphid, usually exhibits a yellowish-green coloration, occasionally appearing as a dull pink. This species predominantly infests fruit-bearing shoots. Black eggs are laid on buds, especially on female inflorescences, where they overwinter. *C.avellanae*

produces several generations during the growing season and remains on the hazel tree throughout its life cycle. Sexual forms emerge in autumn, and after mating, eggs are laid on the hazel tree. This aphid primarily feeds on young shoots and is rarely found on leaves; when it does feed on leaves, it prefers areas with short trichomes, such as intermediate vessels [20].

Altica brevicollis Foudras hibernates beneath plant debris. In the spring, specifically during the second decade of April, when air temperatures range between 18-22°C, these insects emerge from their overwintering sites and commence egg-laying after feeding on newly expanded leaves of hazel and oak. Eggs are deposited in clusters, with each cluster containing 20-28 eggs, on the underside of the leaves. Under controlled laboratory conditions, egg development spans 12-14 days, while in natural conditions it extends to 16-22 days. By the second decade of May, larvae begin to emerge from the eggs, with a peak in larval emergence occurring at the end of May. The developmental period of the egg stage for the second generation is 15-18 days, and the larval stage lasts 24-26 days. The larval development period extends from 26-32 days; following three instar stages, larvae descend into the soil and pupate at a depth of 2-3 cm. *Altica brevicollis* Foudr. produces two generations per year in this region. Additionally, 16 species of parasitic and predatory insects contribute to the control of leaf-eating populations [22].

Other notable pests include *Phytoptus Avellanae* Nal., the European fruit *Lecanium* (*Parthenolecanium corni* (Bouché)), and the nut weevil (*Curculio nucum* L.).

Rodents are often neglected in discussions of hazelnut pests, despite their significant impact on hazelnut productivity. Notably, the European edible dormouse (*Glis glis* L.) plays a prominent role in this context. The most recent colonization wave of the edible dormouse in the Greater Caucasus originated from Europe [23]. Due to its nutritional adaptability and other biological characteristics, the edible dormouse has expanded its habitat to include parks and gardens, forming independent wild populations in newly occupied geographic regions [24]. Ghirardi et al. [25] investigated the impact of *Glis glis* L. on hazelnut production, revealing that this species can inflict substantial damage. Their research demonstrated that the density of *Glis glis* L. was higher in orchards than in forested edges, with peak activity occurring from late July to mid-August. The dormice were responsible for a 61% reduction in hazelnut yield, with approximately 25% of this loss due to fruit gnawing. The proportion of ripe fruit yield

was less than 40%, with the most severe damage occurring in orchards near forested areas. Key orchard characteristics, such as proximity to wooded zones and dense leaf canopies, were associated with higher dormouse densities and increased damage levels. Additionally, Rodolfi [26] documented that the dormouse's consumption was consistently high, averaging 31.7 and 20.5 hazelnuts per day during the second half of July 1988 and the first half of July 1989, respectively.



Figure 5. Damage to hazelnuts by *Glis glis* L.

Estimation of Hazelnut Consumption by *Glis glis* L.

To assess the potential damage caused by *Glis glis* L. on hazelnut production, we can estimate the average number of hazelnuts consumed by dormice per hectare. According to Ghirardi et al. [25], dormice density in hazel orchards can vary significantly, with recorded values ranging from a minimum of 4.13 dormice per hectare to a peak density of 247 dormice per hectare.

The daily intake of hazelnuts by a single dormouse (*Glis glis* L.) has been reported by Rodolfi [26] to be between 20.5 and 31.7 hazelnuts per day, depending on the year, month and conditions. Additionally, the average weight of a fresh hazelnut from the Ata-baba cultivar is approximately 2.5 grams [5]. Using these figures, we can estimate the total weight of hazelnuts consumed per hectare over a 30-day period:

Total Hazelnuts Consumed per Day = Dormice Density per Hectare × Daily Intake per Dormouse
Total Hazelnuts Consumed Over 30 Days = Total Hazelnuts Consumed per Day × 30

Total Weight of Hazelnuts Consumed (kg) = Total Hazelnuts Consumed × 2.5 grams/hazelnut ÷ 1000

Damage assessment can be estimated by considering two scenarios: one representing minimum damage and the other representing maximum damage.

These calculations reveal the substantial potential for damage, especially in orchards where dormice densities are high. They underscore the importance of implementing effective dormouse management

strategies to protect hazelnut yields in areas prone to high *Glis glis* L. activity.

Table 1. Estimated hazelnut consumption by *Glis glis* L. under minimum and peak population density scenarios

Scenario	Dormice density (per hectare)	Daily intake per dormouse (hazelnuts)	Total hazelnuts consumed over 30 days	Total weight of hazelnuts consumed (kg)
Minimum Density Scenario	4.13	20.5 (Min) / 31.7 (Max)	2,540 (Min) / 3,928 (Max)	6.35 (Min) / 9.82 (Max)
Peak Density Scenario	247	20.5 (Min) / 31.7 (Max)	151,905 (Min) / 234,897 (Max)	379.76 (Min) / 587.24 (Max)

While fat dormouse (*Glis glis* L.) is known to cause damage to hazelnut orchards, it is important to comply with laws when addressing this issue. According to the Azerbaijani Cabinet of Ministers' Decision No. 176, approved on November 6, 2004, the dormouse is a protected species, and any actions that harm or kill this animal are strictly prohibited and subject to fines. This decision is part of the regulations under the "Rules for State Control in the Protection and Use of Animal Species," which also outlines fines for illegal hunting. Therefore, orchard management should focus on non-lethal methods that align with legal and conservation requirements.

In the hazel orchards located in proximity to the mountainous regions of Azerbaijan, forest fauna, particularly jackals, consume the fallen nuts in substantial quantities. To mitigate this impact and protect the yield, implementing measures such as covering the orchards with protective netting or using other non-lethal deterrents could be effective. These methods aim to safeguard the crop while minimizing harm to the local wildlife, ensuring a balanced approach to both agriculture and conservation.

CONCLUSION

Hazelnut cultivation in Azerbaijan holds substantial potential both historically and economically. The industry has witnessed significant growth, particularly in the Sheki-Zagatala region, which remains the epicenter of production. While traditional methods persist, there is a growing shift towards modern agricultural practices to meet the increasing global demand. The preservation of local cultivars and the management of challenges such as pests and diseases are critical to sustaining and enhancing hazelnut production. With strategic investments and continued research, Azerbaijan's hazelnut industry is well-positioned to expand its influence in the global market.

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