Turkish hazel *(Corylus colurna L.)* in Hungary:
A case study on its forestry potential

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Summary: This study investigates the structure and growth of a 73-year-old Turkish hazel (*Corylus colurna* L.) plantation in Hungary. The stand had a tree density of 290 per ha, mean height of 18.2 m, quadratic mean diameter of 34.2 cm, and a basal area of 26.7 m² ha⁻¹. The slenderness ratio of 0.55 indicates moderate stability. Diameter distribution was normal (22–53 cm). Crown structure parameters showed moderate correlations with diameter (R^2 = 0.59 for crown diameter; R^2 = 0.53 for crown projection area), emphasizing the role of crown traits in yield modelling. An optimal planting density of 434 trees ha⁻¹ was estimated based on the average crown projection area (23 m²). Turkish hazel, with its drought resilience and valuable wood, is a promising species for afforestation in semi-arid climates. However, further research is needed on its management and genetic improvement to support wider application. This study can be considered gap-filling both in a Hungarian and, to some extent, an international context.

Key words: plantation forestry, non-native tree species, *Corlyus* sp.

Introduction

The Turkish hazel (*Corylus colurna* L.) is a thermophilic, tree-form hazel species native to Southeast Europe (Balkan Peninsula), Asia Minor, the Caucasus, and Afghanistan. It is primarily a tree of hilly and lower montane regions. Its use around the Black Sea dates back to Before the Common Era, and its principal growing area remains in present-day Turkey. In Europe, its northern distribution limits approach the southern border region of Hungary and Romania (Alexandrov, 2014; Šeho et al., 2019). Beyond Europe and Asia, it is also intensively cultivated along the Pacific Coast of the United States, notably in Oregon, where it is increasingly used as a non-suckering rootstock and component in hazelnut breeding programs (Pacchiarelli et al., 2022).

It is characterized by broad-ovoid leaves that are heart-shaped at the base and taper to a pointed apex. Leaf size typically ranges from 6 to 15 cm in length and 5 to 13 cm in width. The margins are distinctly double-serrated or coarsely toothed, and in some cases, slightly lobed. The species produces unisexual flowers that appear in early spring prior to leaf emergence. Male catkins, pale yellow in color, reach lengths of approximately 5–10 cm, whereas the female inflorescences are minute, showing only red styles (1–3 mm long) emerging from greenish buds. The nuts ripen by September and contain edible kernels with a flavor closely resembling that of the common hazel (*C. avellana* L.). Each nut, measuring about 1–2 cm in length, is enclosed in a thick, softly spiny, bristly involucre. Typically, three to eight nuts develop together, forming dense clusters. (Kalkan et al., 2023). It can reach heights of 25 to 35 m, and diameter at breast height of 50 to 60 cm, depends on site quality (Richter, 2013; Alexandrov, 2014; Šeho et al. 2017, 2023; Vojnikovic et al., 2025).

Site requirements and afforestation considerations

The Turkish hazel has modest site requirements (Pauls, 2006; Alexandrov, 2014). However, when applied as a forest stand in Hungary, it is recommended for pure plantation-style establishment or as a block mixture within sessile oak (*Quercus petraea* (Matt.) Liebl.) and downy oak (*Quercus pubescens* Willd.) afforestation, preferably on soils free from defects, with medium to deep rooting depth. Suitable soil types include brown forest soils, colluvial soils, rusty brown forest soils, brown forest soils with carbonate residues, chernozem brown forest soils, and combinations involving humus-rich sand.

The species is tolerant of climatic extremes and withstands polluted urban air well, which occurs frequently in many areas. It is fully winter-hardy throughout Central Europe. It has been successfully planted in urban greening projects and as roadside tree rows, even in the driest regions of the country. Due to these favorable characteristics, its reintroduction into closed afforestations (specifically plantation-style forest establishments) may be considered, particularly under increasingly semi-arid climatic conditions, where it could serve dual purposes: timber and nut production (Richter, 2019; Šeho et al., 2019; Hovakimyan et al., 2024; Sandholz et al., 2024; Vojnikovic et al., 2025).

For afforestation purposes, Turkish hazel is typically established using 1+0 or 2+0 seedlings with heights ranging from 50 to 80 cm (Richter, 2025). In contrast, urban plantings commonly utilize taller planting stock exceeding 120 cm in height to meet aesthetic and functional requirements (Šeho et al., 2017; Vojnikovic et al., 2025). Transplants (1+1, 1+2) are

avoided due to damaged taproots (Richter, 2025). Planting is carried out in early spring before bud swelling, with adequate soil moisture being critical for survival (Pauls, 2006; Richter, 2017). It is planted either as individual trees or in groupings (Ruhm, 2013; Vojnikovic et al., 2025). In mixed-species plantations, planting spacings vary: 5×1.5 m is typically applied when interplanted with wild cherry (*Prunus avium* L.), while 5×2.5 m is used alongside small-leaved lime (*Tilia cordata*). On abandoned agricultural land, wider spacing (3×3 to 7×7 m) is common, whereas forest gaps require denser planting (2×1 m or 2×2 m) (Richter, 2013; Vojnikovic et al., 2025). In degraded forest areas, it is introduced in clusters of 13–24 seedlings at 1×1.5 m spacing, with 15 m between nests, resulting in 577–1066 seedlings per hectar (Richter, 2014).

Afforestation with Turkish hazel require regular tending until the age of 4–5 years and must be protected from wildlife damage using fencing. The species can also be introduced as a scattered admixture among slow-growing tree species (primarily oaks) as a replacement; however, it is not recommended for mixing with fast-growing species. The production of high-quality wood suitable for carpentry and furniture manufacturing requires a closed stand structure (Šeho et al., 2019; Vojnikovic et al., 2025). Knowledge concerning stand improvement (tending) remains very limited, as forest stands of Turkish hazel in Hungary are rare and currently cover only a few hectares.

In this study, we presented a stand structural analysis of a Turkish hazel stand in Hungary, as a case study.

Materials and methods

The studied Turkish hazel stand is located near the village of Alsószentiván, within a forest-steppe climate zone, on a free-draining site. The soil is a chernozem with a sandy loam texture, based on site typology by Járó (1972). The forest subcompartment covers an area of 0.4 hectares. The experimental site is part of the Mezőföld (Tengelic Sands) forestry microregion, where the long-term average annual precipitation is 574 mm, and the mean annual temperature is 10.5 °C (Führer, 2017).

In the 73-year-old stand, measurements were carried out for tree height (h), diameter at breast height (dbh), and crown diameter (CD). The basal area (ba) was also calculated.

These parameters were calculated at the stand level. The height of the stands (H_L) was derived using Lorey's formula (Lorey, 1878), while stand diameter was expressed as the quadratic mean diameter (QMD) (Curtis and Marshall, 2000). Basal area (BA) and stem number (N) per hectare were also determined. To characterize tree stability, the slenderness ratio (H/D ratio) was used, which is defined as the ratio of tree height (H) to diameter at breast height (D). This ratio is a key indicator of mechanical stability, as higher values indicate more slender trees that are generally more susceptible to windthrow and snow damage (Pretzsch, 2009).

For the crown structure analysis, crown projection area (CPA) was calculated from crown diameter values using the following equation:

$$CPA = CD^2 \frac{\pi}{4}$$

Statistical analysis

An analysis was conducted on the distribution of dbh values, which revealed that the data set conforms to a normal

distribution. The experimental stand was evaluated as a function of CD-dbh, and CPA-dbh, using linear and second-order functions. IBM SPSS ver. 25.0 and MS 365 Excell software packages were used for statistical analysis.

Results

In the studied Turkish hazel stand (N = 290 trees ha^{-1}) the average height (H) was 18.2 m, the diameter (QMD) was 34.2 cm, and the basal area (BA) amounted to 26.7 m² ha^{-1}. According to a review by Vojnikovic et al. (2025), it culminates in growth by age 40. Slenderness ratio was 0.55 (55%), which suggests moderate tree stability (Pretzsch, 2009). The key stand structural parameters are summarized in *Table 1*.

Table 1. Key stand structural characteristics (subcompartment Alsószentiván 23 D).

Age	H_L	QMD	H/D ratio	N	BA
	(m)	(cm)		(stem ha^{-1})	(m² ha^{-1})
73	18.2	34.2	0.55	290	26.7

We also studied the distribution of dbh values (*Figure 1*). According to Kolmogorov-Smirnov test, data follow normal distribution (p=0.93). The range was 31, varied between 22 cm (minimum) and 53 cm (maximum). The maximum of the distribution (frequency) is 19.
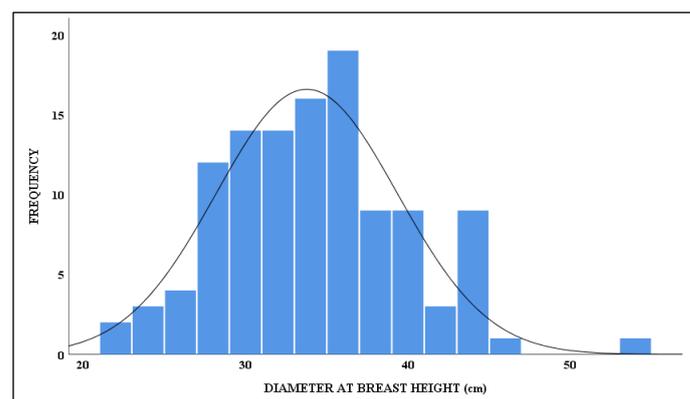

Figure 1. Distribution of diameter at breast height values.

For crown structure analysis, we fitted lines between the dbh and CD (*Figure 2*), and dbh and CPA (*Figure 3*) values of the trees of the whole dataset to estimate the linear regressions. The fit of the regression lines was acceptable, with R² values of 0.59 and 0.53, respectively, indicating moderate correlations between the studied parameters.
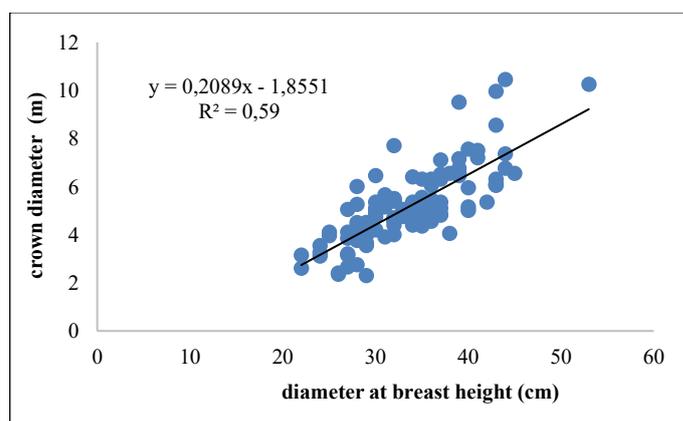

Figure 2. Linear correlation between crown diameter (CD) and diameter at breast height (dbh) of individual trees (n = 116) of a 73-year-old Turkish hazel stand.
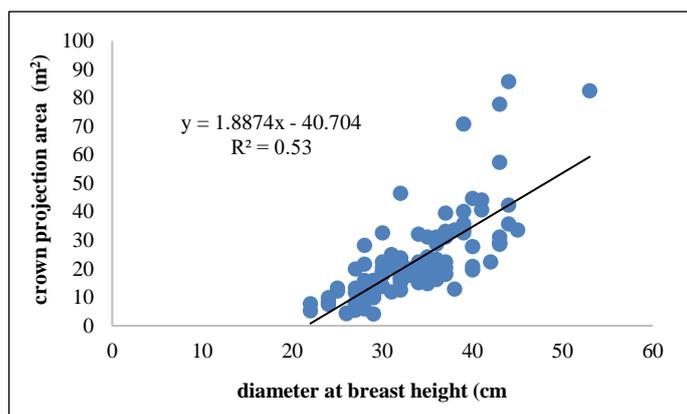
Figure 3. Linear correlation between crown projection are (CPA) and diameter at breast height (dbh) of individual trees (n = 116) of a 73-year-old Turkish hazel stand.

Using CPA value (average CPA of measured trees is 23 m^2) the stem number per hectare was determined with the following formula: N = 10000/CPA, 10000/23. Assuming that the targeted diameter is 34.2 cm, the suggested N is 434. It has great importance in Turkish hazel plantation planning.

The results indicate a clear correlation between crown characteristics and stand productivity. Notably, CD and CPA is closely linked to dbh, a key determinant of tree volume (Rédei et al., 2018). This suggests that crown dimensions significantly influence the growth performance of Turkish hazel. Understanding these relationships can enhance our ability to predict yield and inform silvicultural decisions aimed at maximizing wood production in managed stands.

Discussion

Non-native tree species may become increasingly important role in the future forest management (Tama et al., 2025). Due to its wood quality Turkish hazel is a suitable alternative to native tree species, such as European beech (*Fagus sylvatica* L.) (Zeidler, 2012; Šeho, 2023). It is capable of withstanding prolonged drought and low temperatures, making it particularly suitable for regions exposed to climatic extremes. With appropriate silvicultural practices, it can enhance the stability of mixed stands and support sustainable timber production under increasingly variable climate conditions (Richter, 2019; Sandholz et al., 2024). Although Turkish hazel exhibits faster growth than sessile oak, its comparatively lower drought tolerance may limit its competitiveness in oak-dominated stands or among other native species on dry sites (Richter, 2017).

Genetic conservation of this tree species plays a key role in sustainable forest development (Šeho et al., 2019). Comprehensive genetic testing, including both provenance and progeny trials, should be undertaken to determine the most appropriate seed sources and genetic families for afforestation efforts in semi-arid regions (Temel et al., 2017).

Conclusions

This study can be considered gap-filling, as there are very few comparable investigations and evaluations of Turkish hazel stands with approaching harvest rotation age. Although not native to Hungary, Turkish hazel (*Corylus colurna* L.) is considered a species of renewed interest due to its valuable wood, high drought tolerance, and established role in urban landscaping. Thus, it represents a promising alternative tree species for afforestation under increasingly extreme environmental conditions. The species shows potential for both wood and nut production, particularly in semi-arid regions. However, due to limited silvicultural experience, further studies are needed on growing technology and genetic improvement to support wider application.

Mitigating the adverse effects of global and local climate change is among the primary objectives of international forest science. The potential solutions are diverse, and under deteriorating ecological conditions, non-native tree species may also have a role—either as main stand-forming or as admixed tree species.

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