Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 16(1), 58-71, 2026
Journal of the Institute of Science and Technology, 16(1), 58-71, 2026
ISSN: 2146-0574, eISSN: 2536-4618
Plant Protection **DOI: 10.21597/jist.1727373**
Review Article
Received: 25.06.2025 **Accepted: 17.10.2025**

To Cite: Güney Sarıtaş, A., & Gürbüz, R. (2026). *Ailanthus altissima* (Mill.) Swingle an Invasive Tree Species: Botanical Characteristics, Ecological Effects and Management Strategies. *Journal of the Institute of Science and Technology*, 16(1), 58-71.

Ailanthus altissima **(Mill.) Swingle an Invasive Tree Species: Botanical Characteristics, Ecological Effects and Management Strategies**

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Highlights:
- Rapid spread
- Habitat pressure
- Control strategies

Keywords:
- *Ailanthus altissima*
- Invasive species
- Ecological impact
- Control methods
- Allelopathy
- Phytoremediation

ABSTRACT:

Ailanthus altissima (Mill.) Swingle (tree of heaven) is an invasive tree species native to Asia that spreads rapidly and has a high adaptability. It spreads rapidly and forms colonies, especially in disturbed areas, along roadsides, and in forest clearings. *A. altissima* spreads through its rapid growth capacity, root suckers, and wind-borne seeds. Additionally, its tolerance to environmental stress factors enables it to become dominant in natural ecosystems. This review article examines the botanical characteristics, distribution areas, ecological impacts, control methods, and potential uses of *A. altissima* based on a literature review. It has been determined that the plant suppresses the growth of surrounding plant species through allelopathic effects, alters soil microbial structure, and threatens biodiversity. Additionally, it has negative effects on fire regimes, creates erosion risks, and causes habitat loss for native fauna. Mechanical, chemical, and biological control methods are discussed in the context of control measures. It has been emphasized that the most effective results are achieved through the integration of these methods. In particular, studies on systemic herbicides and biological control agents offer new approaches to controlling the species. Additionally, this species has beneficial aspects in areas such as wood production under controlled conditions, erosion prevention, traditional medicine, and phytoremediation. In conclusion, the uncontrolled spread of *A. altissima* poses a serious threat to ecosystems. To mitigate the impact of this issue, integrated control strategies developed with the collaboration of both public institutions and scientists, based on scientific data, and sustainable control strategies must be developed.

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INTRODUCTION

Invasive plant species become more dominant than other species in their ecosystem due to various characteristics. These species are more dominant than native species due to their rapid growth capabilities, deep and extensive root systems, high reproductive potential, allelopathic effects, and broad adaptation capacities. When the invasive plants settle in a new region, they cause a significant decrease in the number and density of local plant populations (Mehrhoff, 1998; Yang *et al.,* 2012; Uludağ & Önen, 2015). The increased spread of invasive species has negative effects on biological diversity. Especially in invaded areas, the dominance of these species leads to a decrease in species diversity in the ecosystem (Vila *et al.,* 2010). *Ailanthus altissima* (Mill.) Swingle, commonly known as the "tree of heaven," is a fast-growing, deciduous tree belonging to the Simaroubaceae family. Originating in Central and East Asia, this species was introduced to Europe and North America in the 18th century as an ornamental plant. Over time, it has spread worldwide through various means and become invasive. *A. altissima* is a species that has spread across all continents except Antarctica (Kowarik & Säumel, 2007). However, its use as an ornamental plant has gradually decreased due to its invasive nature (Sladonja *et al.,* 2015; Soler & Izquierdo, 2024).

Although *A. altissima,* grows better in warm climates, it can easily settle in different climate conditions (Sladonja *et al.,* 2015; Soler & Izquierdo, 2024). This situation clearly demonstrates how difficult it is to control the species and its invasive potential. Additionally, this species can reproduce both via seeds and vegetatively, enabling it to spread rapidly over vast areas (Lamarque *et al.,* 2011). Numerous weed species cause problems in agricultural and non-agricultural areas (Alptekin *et al.,* 2022; Tülek *et al.,* 2022; Güney Sarıtaş & Gürbüz, 2024; Gürbüz *et al.,* 2024; Gürbüz & Alptekin, 2024; Taşkın *et al.,* 2025). *A. altissima* is commonly observed in agricultural lands, forested areas, parks, streets, and roadside areas (Call & Nilsen, 2003). In Turkiye, *A. altissima* has drawn attention in recent years due to its increasing spread and is commonly observed in recreational areas.

Figure 1. Images of *Ailanthus altissima* found along roadsides

The aim of this compilation study is to examine the biological and ecological characteristics of *A. altissima* in greater depth. It also aims to address in detail the reasons for the spread of this invasive species and its effects on ecosystems. The botanical characteristics, dispersal biology, ecological impacts, and control methods of *A. altissima* will be examined in accordance with current scientific literature. The current situation in Turkiye and recommendations for the future will be evaluated. Thus, the aim is to contribute to both academic studies and field applications.

Botanical Characteristics

Ailanthus altissima is a fast-growing tree that can reach 20-30 m in height and has a broad, spreading crown. The leaves are 30–90 cm long and contain 11–41 leaflets. The leaflets are lanceolate, 5–15 cm long, with entire or sparsely toothed margins and acute tips. There are noticeable swellings at the base of the leaf stalk. When crushed, it emits a characteristic "bad smell" (oily-cheesy), which is one of the distinguishing features of the species. Young shoots are hairy, reddish-brown in color, and have noticeable lenticels. The flowers, which bloom in June-July, are greenish-yellow in color, small (5-7 mm in diameter), and appear in dense compound clusters. The flowers are dioecious (two-sexed); male and female flowers are typically found on separate individuals. They contain 10–20 stamens (male organs) and emit a distinct fragrance. They have a 3–5-carpellate ovary. The fruits are 3–5 cm long, single-seeded, and winged. When ripe, they turn reddish-brown in color (Kowarik & Säumel, 2007). The seeds develop in dense clusters during the summer, mature in early autumn, and typically remain on the tree until spring. Wind-dispersed seeds can travel distances exceeding 200 m, enabling them to grow in wide areas (Landenberger *et al.,* 2007; Atar and Turna, 2022).

Ailanthus altissima has a highly spreading root system. In addition to the main root, lateral roots spread horizontally and affect the soil structure around them. This root structure both alters the water retention capacity of the soil and damages infrastructure systems (Ding *et al.,* 2006). Additionally, when cut or damaged, it rapidly produces new shoots from the roots and stem. Table 1 provides information on how *A. altissima* competes with native species and with which species it interacts more frequently.

Figure 2. Images of the morphology of *Ailanthus altissima*

Table 1: Competition Type and Effects of *Ailanthus Altissima* on Native Plant Species

Native Species	Competition Type	Effects
***Betula* spp. (Birch)**	Space Competition	Inhibits the growth of birch trees and takes control over the soil (Isler *et al.,* 2023).
***Populus* spp. (Poplar Species)**	Light Competition	*A.altissima* grows faster and blocks sunlight (Isler *et al.,* 2023).
***Quercus* spp. (Oak Species)**	Root and Allelopathic Competition	*A. altissima* negatively affects the root development of oak species through allelopathic compounds, making it harder for them to access water and nutrients (Bauman *et al.,* 2013).

Spread Bıology and Invasıve Characterıstıcs

Ailanthus altissima has the capacity to produce up to 300.000 seeds per year (Kowarik & Säumeli, 2007). These seeds are dispersed over wide areas by wind due to their winged structure (Bossard *et al.,* 2000; Kaproth & McGraw, 2008; Planchuelo *et al.,* 2016). The seeds remain viable in water for extended periods (Kaproth & McGraw, 2008; Soler & Izquierdo, 2024). *A. altissima* is recognized as one of the most invasive species globally due to its high dispersal capacity and ecological impacts (Soler & Izquierdo, 2024). *A. altissima* is considered an invasive tree species due to its rapid spread and suppression of native species in ecosystems (USDA, 2025; CABI 2025). One of the most notable invasive characteristics of this species is its allelopathic effects. The secondary metabolite ailanthone inhibits the growth of surrounding plants by suppressing their underground and above-ground development processes (Kowarik & Säumel, 2007). Its introduction into a country or area generally occurs intentionally by humans. This is because the plant is imported and planted as an ornamental plant, erosion control plant, and reforestation plant (Uludağ & Önen, 2015). The spread rate of *A. altissima* and its effects on ecosystems in different geographical regions or over the years are compared in Table 2.

Table 2. Spread Rate and Ecosystem Impacts of *Ailanthus Altissima*

Region	Spread Rate (Yearly Basis)	Impact on Ecosystem
North America	Rapid (spreads within 10–15 years)	Decline in native vegetation, soil erosion (Kowarik & Säumel, 2007; Sladonja et al., 2015).
Europe	Moderate (spreads within 15–20 years)	Threatens biodiversity, disrupts ecosystem balance (Isler *et al.,* 2023; Kowarik, 2010).
Asia (Native Range)	Slow (localized spread)	No significant negative impacts observed in natural habitats (Hu, 1979; Bory & Clair-Maczulajtys, 1980).

Ecological Impacts

Ailanthus altissima typically grows in disturbed areas (e.g., fallow agricultural land, roadsides, etc.). It prefers rich, moist soils but tolerates poor, dry soils. The tree of heaven is widely found in urban areas worldwide because it tolerates air pollution and can trap pollutants (Ding *et al.,* 2006). The tree of heaven can also cause economic losses and human health issues. Its strong root system has been reported to damage sewer lines and foundations (Hu, 1979). The pollen of the tree of heaven has been recorded as a potential allergen (Ballero *et al.,* 2003). *A. altissima* can also cause a reaction when its sap comes into contact with human skin (Derrick & Darley, 1994). *A. altissima* is an invasive species that increases erosion risk by reducing soil stability. First, it has a strong allelopathic effect; chemicals such as ailanton secreted from its root and leaf tissues suppress the germination and growth of other plant species in its vicinity, reducing the density and diversity of the local vegetation. This leads to the disappearance of natural vegetative cover that protects the soil from the physical impact of raindrops and surface runoff. Thus, it facilitates the transport of soil particles. Secondly, having a more superficial root structure instead of forming a deep and fibrous root system that tightly envelops the soil is insufficient for holding the soil together (Kowarik & Säumel, 2007).

A decrease in the C/N ratio in the soil leads to structural changes in microbial activity (Voutos *et al.,* 2021). Soil microbial communities are directly affected by the compounds secreted by *A. altissima.* These effects lead to a decrease in microbial diversity, disruption of symbiotic relationships, and consequently, weakening of the ecosystem (Voutos *et al.,* 2021). Additionally, *A. altissima* leaves and dry branches with low moisture content can increase the fire risk (Kota *et al.,* 2007). The negative effects of *A. altissima* on the ecosystem and a comparison with the ecosystem services provided by native plants are presented in Table 3.

Table 3. Effects of *Ailanthus altissima* on Ecosystem Services

Ecosystem Service	Impact of ***Ailanthus altissima***	Services Provided by Native Species	References
Soil Erosion	Reduces soil stability; increases erosion risk	Protects soil with deep root systems	(Kowarik & Säumel, 2007;Sladonja *et al.,* 2015)
Biodiversity	Suppresses native species; reduces habitat diversity	Enhances diversity by creating varied habitats	(Vila *et al.,* 2011; Hejda *et al.,* 2009; Heisey, 1990;Call & Nilsen, 2003)
Water Quality	Increases nutrient (N, P) runoff into surface waters due to leaf litter and erosion	Improves water quality through natural filtration and evapotranspiration	(Kowarik & Säumel, 2007;Vila *et al.,* 2006)
Carbon Storage	Limited carbon sequestration due to low wood density and short lifespan	Longer-lived, high-biomass species store more carbon	(Nowak & Crane, 2002)

CONTROL AND MANAGEMENT METHODS

Ailanthus altissima is known worldwide as an invasive species. The negative impacts of this species on local ecosystems (loss of biodiversity, competition with native species, allelopathic effects, etc.) and the damage it causes to infrastructure (damage to building foundations, clogging of sewer lines, etc.) necessitate its control. Control and management methods vary depending on the tree's biological characteristics, the extent of the invasion, and the characteristics of the area where the measures will be implemented. The best results are typically achieved through an integrated approach that combines different methods.

Mechanical Control

Mechanical control is performed manually or with any tool, but it is effective against seedlings. This is because cutting or breaking the roots after the root system has developed encourages regrowth (Hu, 1979). Additionally, repeated cuts increase the number of shoots (Sladonja *et al.,* 2015;Soler & Izquierdo, 2024). Once *A. altissima* has formed taproots, it is very difficult to remove. All applications require monitoring and control of shoots emerging from remaining seeds, roots, or stumps. A study by Constán-Nava *et al.,* (2010) tested the effectiveness of controlling *A. altissima* by cutting and cleaning the roots. This method must be performed regularly to prevent *A. altissima* from regrowing. The study noted that the success achieved through mechanical control is effective in limiting the spread of the species. However, it also showed that these species must be monitored throughout the year to prevent regrowth. Mechanical control is very ineffective in controlling this species in mature trees. For example, studies have shown that herbicides such as glyphosate, imazapyr, picloram, triclopyr, or 2,4-D provide better control than mechanical methods alone (Fogliatto *et al.,* 2020; Meloche & Murphy, 2006; Young *et al.,* 2020;Soler & Izquierdo, 2024). When comparing herbicide application to cut stumps with glyphosate, imazapyr, or triclopyr versus cutting alone, herbicide-treated trees produced fewer sprouts than untreated trees (DiTomaso & Kyser, 2007;Soler & Izquierdo, 2024). Similarly, it has been reported that applying herbicides to cut stumps resulted in nearly a 90% mortality rate, compared to a 52% mortality rate with cutting alone (Johnson, 2011;Soler & Izquierdo, 2024). The combined use of mechanical and chemical control has been shown to yield better results than chemical control alone (Constán-Nava *et al.,* 2010; Meloche & Murphy, 2006;Soler & Izquierdo, 2024). As indicated in Table

5, mechanical control can be applied in a controlled manner without the need for chemical use. However, the high labor requirements and the risk of regrowth reduce the effectiveness of this method (Miller *et al.,* 2013).

Chemical Control

Chemical control methods involve the direct application of herbicides to the tree or cut surface. Systemic herbicides (e.g., those containing glyphosate or triclopyr) are transported within the plant to the root system, providing more effective control. Application methods include foliar application (for small shoots), bark application (direct application to the tree's bark), and cut surface application (application to the cut surface of the tree) (Soler & Izquierdo, 2024). Systemic herbicides (such as glyphosate, triclopyr, and imazapyr) are transported to the roots along with the plant's sap, providing complete control. The most effective time for application is in the fall, as the plant draws nutrients toward the roots, allowing the herbicide to be transported more effectively (EPPO, 2020; Soler & Izquierdo, 2024). Herbicides are applied to trees using different techniques. Trunk injection involves drilling holes into the trunk with a drill and injecting the herbicide. Undiluted glyphosate provides the best results. Triclopyr and imazapyr can also be used, but their effectiveness may vary. The advantage is that it is effective on large trees and has a low risk of spreading to the environment (Venegas & Pérez, 2009; Soler & Izquierdo, 2024). Bark application involves spraying the herbicide on the lower part of the uncut tree (first 50 cm). Diluted triclopyr generally yields good results (Burch & Zedaker, 2003; Johnson, 2011; Eck & McGill, 2007; Bowker & Stringer, 2011; Soler & Izquierdo, 2024). Since it is not sufficient on its own for large trees, a mixture (triclopyr + fluroxypyr) can be tried. Its advantage is that it does not require cutting and is effective on small to medium-sized trees (Fogliatto *et al.,* 2020; Soler & Izquierdo, 2024). In the cut stump application, the herbicide is sprayed or injected onto the cut surface immediately after the tree is cut. Undiluted glyphosate or triclopyr provides complete control (Venegas & Pérez, 2009; Soler & Izquierdo, 2024). Diluted formulations may be insufficient (Fogliatto *et al.,* 2020; DiTomaso & Kyser, 2007; Soler & Izquierdo, 2024). Metsulfuron methyl (granular form) is partially effective but does not provide complete control (Johnson, 2011; Soler & Izquierdo, 2024). Its advantage is that it is one of the most effective methods for preventing root sprouting. Furthermore, according to Table 5, chemical control provides high efficacy in controlling *A. altissima* in a short period of time. However, it should be applied with caution due to the risk of harming native species and causing environmental pollution (DiTomaso *et al.,* 2013).

As a result, three main methods are used in the chemical control of *A. altissima*: trunk injection, basal bark application, and the cut stump method. Trunk injection ensures systemic transport by delivering the active ingredient directly into the vascular tissues. This method is particularly effective on large-diameter trees (>10 cm) and is recommended for application in spring and autumn. Undiluted glyphosate is the most common herbicide used in this technique. Basal bark application is based on applying herbicide to the bark at the base of the trunk. It can be applied throughout the year in frost-free conditions, and diluted triclopyr is effective. The cut stump method involves applying herbicide to the surface after cutting the tree. Early fall is the most suitable time, as this is when the plant transfers nutrients to the roots. Glyphosate or triclopyr can be used in this method. (Soler & Izquierdo, 2024).Suitable methods and application times for the chemical control of *A. altissima* are provided in Table 4.

Table 4. Suitable Chemical Control Methods and Application Times for *Ailanthus altissima*

Method	Best Time	Application Area (Tree Size)	Effective Herbicides
Stem Injection	Spring–Fall	Large trees (>10 cm diameter)	Undiluted glyphosate
Basal Bark	Year-round (no frost)	Small–medium trees	Diluted triclopyr
Cut Stump	Early fall	All sizes	Undiluted glyphosate/triclopyr

Biological Control

Many different organisms have been identified as biological agents of *A. altissima* trees. These natural enemies are arthropods and fungi. Most of them have been found in Chinese ecosystems. Aculus spp. (mites) weaken the leaves by sucking on them, but they do not kill the tree on their own (Marini, 2021; Kashefi *et al.,* 2022; Soler & Izquierdo, 2024). *Lycorma delicatula* (spotted lanternfly) uses *A. altissima* as a host but is used for control purposes (Kreitman *et al.,* 2021; Soler & Izquierdo 2024). Fungi play an important role in the biological control of *A. altissima.* Some *Verticillium, Alternaria*, and *Cercospora* species have shown good results as biological control agents (Ding *et al.,* 2006; Soler & Izquierdo 2024). Common symptoms of trees affected by *Verticillium* include premature leaf drop, yellowing of leaves, and drying and death of branches (Rebbeck *et al.,* 2013; Soler & Izquierdo 2024). Different *Verticillium* species have been effective depending on the climate. *V. dahliae* is reported to be effective in warm regions, while *V. nonalfae* is effective in colder regions (Maschek & Halmschlager 2017; Soler & Izquierdo 2024). As shown in Table 5, biological control offers an environmentally compatible and sustainable solution through the use of natural enemies. However, its effects take time to manifest, and adverse effects on non-target species may occur (Caramelo *et al.,* 2021).

Integrated Control

The most effective *A. altissima* control strategy is usually an integrated approach that combines different methods. This approach can be adapted according to the extent of the infestation, the characteristics of the area, and the available resources. For example, in a large infested area, mechanical methods can be used to remove a large portion of the trees first. A study argues that the most effective method for controlling *A. altissima* is an integrated strategy that combines chemical and mechanical methods (Meloche & Murphy, 2006). Combinations of multiple methods (mechanical cleaning + controlled herbicide + biocontrol) have been identified as the most effective strategy (Lorenzo & Morais, 2023). Although some biological agents have been identified in recent years, their effectiveness in controlling *A. altissima* and their safety on local flora have not yet been definitively determined. Considering the invasive characteristics and spread mechanisms of *A. altissima,* integrated approaches that protect ecological processes and ensure control of the species should be developed (Soler & Izquierdo, 2024). According to Table 5, integrated control combines the advantages of different methods to provide a high level of control. However, it requires careful management due to the high planning and resource requirements (Vilà *et al.,* 2010). Different control methods applied to *A. altissima* are compared in Table 5.

Chemical control is highly effective when systemic herbicides are used. By preventing plants from sprouting again, it offers success rates of up to 85%. This method is preferred because it produces quick results over large areas (DiTomaso & Kyser, 2007). Mechanical control involves physical methods such as cutting or uprooting the tree. The success rate is around 60% due to the need for repeated applications (Kowarik & Säumel, 2007). Biological control has gained importance in recent years, particularly with the use of fungal pathogens such as *Verticillium nonalfalfae.* This method offers a more environmentally compatible and long-term solution. However, it has limited application due to the slow onset of its effects over time and potential risks to non-target species. The success rate of this method is around 40% (Pile

Knapp *et al.,* 2022). Integrated pest management, a preferred method in long-term management strategies, has achieved a success rate of up to 90%. Effective results are achieved by strategically combining chemical, mechanical, or biological methods (Meloche & Murphy, 2006). These data emphasize the importance of an integrated and multifaceted approach in effectively controlling *A. altissima* (Figure 2).

Table 5. Comparison of Control Methods for *Ailanthus altissima*

Control Method	Effectiveness	Advantages	Disadvantages
Chemical Control	High	Fast results, applicable to large areas	May harm native species, risk of environmental pollution (DiTomaso *et al.,* 2013).
Mechanical Control	Moderate	No chemical use, can be applied precisely	Labor-intensive, risk of regrowth (Miller *et al.,* 2013).
Biological Control	Moderate	Eco-friendly, long-term and sustainable solution	Effects may take time, risk of non-target species impact (Caramelo *et al.,* 2021).
Integrated Control	High	Multifaceted and effective, combines advantages of different methods	Requires extensive planning and resources (Vilà *et al.,* 2010).

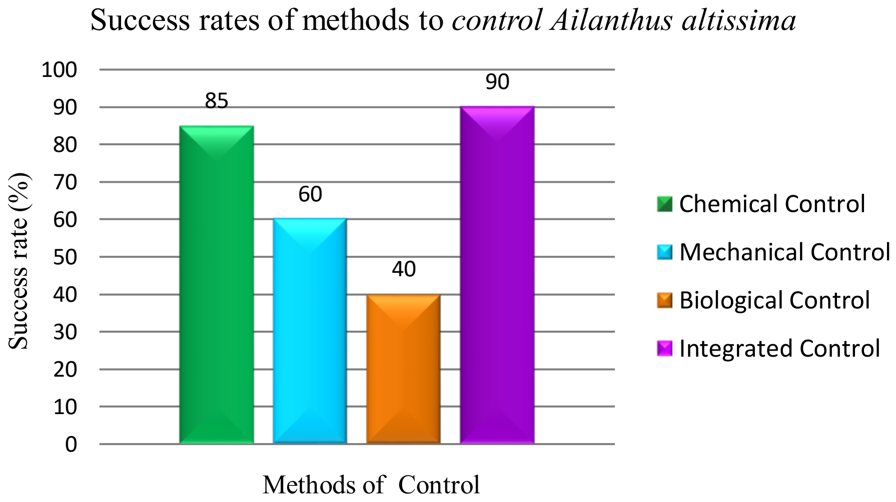

Figure 3. Success rates of methods for controlling *Ailanthus altissima*

In studies conducted to evaluate the effectiveness of different biological control methods, the success rates of various methods were compared. As shown in Figure 3, the “fungi and bacteria” method stands out as the most effective method with a 75% success rate (Pile Knapp *et al.,* 2022). This method is followed by “natural enemies (insects)” with a 60% success rate (Sladonja *et al.,* 2015) and microorganisms with a 50% success rate (Meloche & Murphy, 2006). These findings are important in showing which biological control method yields more efficient results.

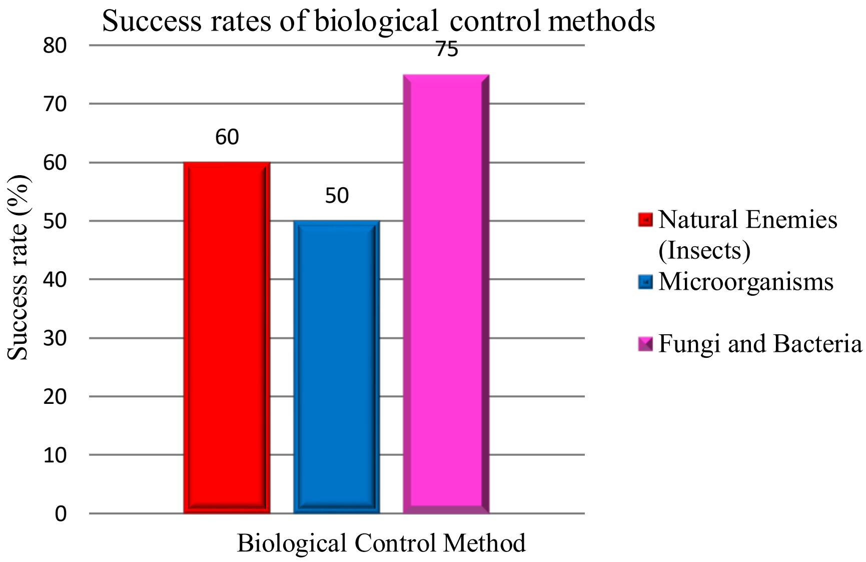

Figure 4. Success Rates of *Ailanthus Altissima* Biological Control Methods.

Areas of Use And Potentıal Value

Despite being an invasive species, *A. altissima* has a wide range of potential uses, ranging from biological processes to industrial applications and environmental remediation. Recent studies have shown that in order to fully realize the value of this species, it needs to be evaluated by bringing together different scientific disciplines.

Wood and Fuel Use

Ailanthus altissima produces wood in a short period of time thanks to its rapid growth capacity. Although the wood is low in density, it is used in areas such as lumber and firewood (Hu, 1979; Kowarik & Säumel, 2007) (Table 6). Its light weight and easy workability also make it suitable for the paper industry (Baptista *et al.,* 2014).

Landscaping and Erosion Control

In the past, *A. altissima* has been widely planted for soil stabilization on roadsides and abandoned industrial lands, especially in areas of dense urbanization. The species' high tolerance to poor soil conditions, heavy metal pollution and air pollution were the main reasons for its preference in urban landscaping (Kowarik & Säumel, 2007; Sladonja *et al.,* 2015) (Table 6). However, due to its invasive character, many countries have abandoned these practices and even banned planting of the species.

Medicinal and Pharmaceutical Potential

Various studies have revealed that extracts from the leaves, bark and roots of *A. altissima* can exhibit antimicrobial, anti-inflammatory and anticancer effects. They stated that these biological activities are related to the compounds named ailanthone and quassinoid found in the plant (Okunade *et al.,* 2003; Wang *et al.,* 2013; He *et al.,* 2016). In traditional Chinese medicine, it has been used for centuries for parasitic (anthelmintic), antipyretic (antipyretic) and antiseptic purposes. Especially the bark parts have been used in the treatment of dysentery and fungal infections (Hu, 1979; Li *et al.,* 2021). However, the clinical validity of these properties has not yet been sufficiently proven and further toxicological research is needed. According to Table 6, biologically active compounds are present in leaf, bark, and root extracts in terms of medical and pharmaceutical potential, and they have a history of use in Chinese medicine. However, clinical data and toxicity limits are still insufficient (Wang *et al.,* 2013; Li *et al.,* 2021).

Phytoremediation (Soil Cleaning) Potential

Ailanthus altissima has been investigated within the scope of phytoremediation studies, especially because it is tolerant to heavy metals such as lead (Pb) and cadmium (Cd). It can be used in environmental cleanup projects due to its ability to grow in soils containing heavy metals and pollution (Sladonja *et al.,* 2015). However, the extent to which the plant absorbs and accumulates these metals and their long-term effects are still not fully understood. The uses and potential values of *A. altissima* are presented in Table 6.

Table 6. Uses and Potential Value of *Ailanthus altissima*

Use Area	Properties and Advantages	Limitations and Risks	References
Wood & Fuel	- Fast wood production and easy ignition - Used for firewood and packaging materials	- Low-density and low-durability wood - Not suitable for high-quality products	(Hu, 1979)
Landscaping & Erosion Control	- Tolerant to air pollution and poor soils - History of use for soil stabilization in abandoned lands	- Banned in many countries due to invasiveness - Risk of uncontrolled spread	(Kowarik & Säumel, 2007; Sladonja *et al.,* 2015)
Medicinal & Pharmaceutical Potential	- Bioactive compounds in leaves, bark, and root extracts - Traditional use in Chinese medicine	- Insufficient clinical data - Uncertainties regarding toxicity and dosage	(Wang *et al.,* 2013; Li *et al.,* 2021)
Phytoremediation	- Tolerant to heavy metals (Pb, Cd, Zn) - Potential for soil cleanup in industrial waste areas	- Unclear bioaccumulation mechanisms - Long-term effects remain uncertain	(Sladonja *et al.,* 2015)

CONCLUSION

Ailanthus altissima is recognized as one of the most problematic invasive tree species worldwide due to its rapid growth, tolerance to environmental stresses and strong dispersal. Although in the past it was valued for erosion control and even medicinal purposes, today its dominant impacts on ecosystems and threats to native flora and fauna have become more evident. Thanks to its botanical characteristics and ecological adaptability, *A. altissima*, which can easily survive in various climatic and soil conditions, is spreading rapidly and suppressing native species, especially in areas such as roadsides, abandoned lands and forest clearings. This has negative consequences not only on biodiversity but also on soil quality, fire risk and ecosystem functioning. The most effective approach to control this species is the integrated application of mechanical, chemical and biological methods. It is also of great importance to support native species and raise public awareness to limit the use of this species. Although it has the potential for some medical and industrial uses, it should be kept in mind that these benefits should only be utilized under controlled conditions. Otherwise, it may cause irreversible damage to ecosystems. In conclusion, increasing scientific studies on *A. altissima,* developing effective control strategies and implementing continuous monitoring programs at the local level will be the key factors in controlling this invasive species.

ACKNOWLEDGEMENTS

Kör makalede bu alan boş bırakılmalıdır. Bu bölüm başlık sayfasında yazılmalıdır.

Conflict of Interest

Kör makalede bu alan boş bırakılmalıdır. Bu bölüm başlık sayfasında yazılmalıdır.

Author's Contributions

Kör makalede bu alan boş bırakılmalıdır. Bu bölüm başlık sayfasında yazılmalıdır.

REFERENCES

Alptekin, H., Gürbüz, R., Özkan, A., & Bozhüyük, A. U. (2022). Mardin ili yabancı ot sorununun ve kimyasal mücadele durumunun belirlenmesi. Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi, 23(1), 84-93.

Atar, F., & Turna, İ. (2022*). Ailanthus altissima* (Mill.) Swingle tohumunun çimlenmesi üzerine ekim zamanı ve yetiştirme ortamının etkisi. *Ormancılık Araştırma Dergisi*, *9*(Özel Sayı), 1-8.

Ballero, M., Ariu, A., & Falagiani, P. (2003). Allergy to *Ailanthus altissima* (tree of heaven) pollen. *Allergy*, *58*(6).

Baptista, P., Costa, A. P., Simões, R., & Amaral, M. E. (2014). *Ailanthus altissima*: An alternative fiber source for papermaking. *Industrial Crops and Products, 52*, 32-37.

Bauman, J., Byrne, C., & Hiremath, S. (2013). *Ailanthus altissima* (Tree-of-Heaven) interferes with beneficial symbionts with negative impacts on oak regeneration. *Journal of the American Society of Mining and Reclamation*, *2*(1), 1.

Bory, G., & Clair-Maczulajtys, D. (1980). Production, dissemination and polymorphism of seeds in *Ailanthus altissima*. *Revue génerale de botanique*, *88*(1049/1051), 297-311.

Bossard, C. C., Randall, J. M., & Hoshovsky, M. C. (Eds.). (2000). *Invasive plants of California's wildlands*. Univ of California Press.

Bowker, D., & Stringer, J. (2011). Efficacy of herbicide treatments for controlling residual sprouting of tree-of-heaven. In *In: Fei, Songlin; Lhotka, John M.; Stringer, Jeffrey W.; Gottschalk, Kurt W.; Miller, Gary W., eds. Proceedings, 17th central hardwood forest conference; 2010 April 5-7; Lexington, KY; Gen. Tech. Rep. NRS-P-78. Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station: 128-133.* (Vol. 78, pp. 128-133).

Burch, P. L., & Zedaker, S. M. (2003). Removing the invasive tree *Ailanthus altissima* and restoring natural cover. *Journal of arboriculture*, *29*(1), 18-24.

Call, L. J., & Nilsen, E. T. (2003). Analysis of spatial patterns and spatial association between the invasive tree-of-heaven (*Ailanthus altissima*) and the native black locust (*Robinia pseudoacacia*). *The American Midland Naturalist*, *150*(1), 1-14.

Caramelo, D., Pedro, S. I., Marques, H., Simão, A. Y., Rosado, T., Barroca, C., ... & Gallardo, E. (2021). Insights into the bioactivities and chemical analysis of *Ailanthus altissima* (Mill.) Swingle. *Applied Sciences*, *11*(23), 11331.

CABI, 2025. Centre for Agriculture and Biosciences International (CABI). 2025. *Ailanthus altissima* (tree-of-heaven) https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.3889? (Accessed October 13, 2025).

Constán-Nava, S., Bonet, A., Pastor, E., & Lledó, M. J. (2010). Long-term control of the invasive tree *Ailanthus altissima*: Insights from Mediterranean protected forests. *Forest Ecology and Management*, *260*(6), 1058-1064.

Derrick, E. K., & Darley, C. R. (1994). Contact reaction to the tree of heaven. *Contact Dermatitis (01051873)*, *30*(3).

Ding, J., Reardon, R., Wu, Y., Zheng, H., & Fu, W. (2006). Biological control of invasive plants through collaboration between China and the United States of America: a perspective. *Biological invasions*, *8*, 1439-1450.

DiTomaso, J. M., & Kyser, G. B. (2007). Control of *Ailanthus altissima* using stem herbicide application techniques. *Arboriculture & Urban Forestry (AUF)*, *33*(1), 55-63.

DiTomaso, J. M., Kyser, G. B., Oneto, S. R., Wilson, R. G., Orloff, S. B., Anderson, L. W., ... & Mann, J. J. (2013). Weed control in natural areas in the western United States. *Weed Research and Information Center, University of California*, *544*.

Eck, W. E., & McGill, D. W. (2007). Testing the efficacy of the triclopyr and imazapyr using two application methods for controlling tree-of-heaven along a West Virginia highway. *e-Gen. Tech. Rep. SRS–101. US Department of Agriculture, Forest Service, Southern Research Station: 163-168 [CD-ROM].*

EPPO, P. (2020). 9/29 *Ailanthus altissima*. OEPP. *EPPO Bull*, *50*, 148-155.

Fogliatto, S., Milan, M. ve Vidotto, F. (2020). On sekizinci yüzyıl kalesinde kesilmiş kütük ve dip kabuğu herbisit uygulamaları kullanılarak *Ailanthus altissima*'nın kontrolü. *Yabancı Ot Araştırması* , *60* (6), 425-434.

Gürbüz, R., Alma, M. H., Alptekin, H., & Tülek, C. (2024). Performance of some organic mulch materials for weed suppression, soil conditions and yield in *Capsicum annuum* L. Cultivation. Journal of the Institute of Science and Technology, 14(1), 18-38.

Gürbüz, R., & Alptekin, H. (2024). Effect of pre-and post-emergence herbicides on weed control and yield in sunflower (*Helianthus annuus* L.). Türkiye Tarımsal Araştırmalar Dergisi, 11(2), 141-156.

He, Y., Peng, S., Wang, J., Chen, H., Cong, X., Chen, A., ... & Liu, M. (2016). Ailanthone targets p23 to overcome MDV3100 resistance in castration-resistant prostate cancer. *Nature communications*, *7*(1), 13122.

Heisey, R. M. (1990). Allelopathic and herbicidal effects of extracts from tree of heaven (*Ailanthus altissima*). *American Journal of Botany*, *77*(5), 662-670.

Hejda, M., Pyšek, P., & Jarošík, V. (2009). Impact of invasive plants on the species richness, diversity and composition of invaded communities. *Journal of ecology*, *97*(3), 393-403.

Hu, S. Y. (1979). Ailanthus. *Arnoldia*, *39*(2), 29-50.

Isler, J., Bugmann, H., Conedera, M., & Thrippleton, T. (2023). Long-term dynamics of tree of heaven (*Ailanthus altissima*) in central European forests. *European Journal of Forest Research*, *142*(5), 1149-1166.

Johnson, J. M. (2011). An Evaluation of Application Timing and Herbicides to Control *Ailanthus altissima*.

Kaproth, M. A., & McGraw, J. B. (2008). Seed viability and dispersal of the wind-dispersed invasive *Ailanthus altissima* in aqueous environments. *Forest Science*, *54*(5), 490-496.

Kashefi, J., Vidović, B., Guermache, F., Cristofaro, M., & Bon, M. C. (2022). Occurrence of *Aculus mosoniensis* (Ripka, 2014)(Acari; Prostigmata; Eriophyoidea) on tree of heaven (*Ailanthus altissima* Mill.) is expanding across Europe. First record in France confirmed by Barcoding. *Phytoparasitica*, *50*(2), 391-398.

Kota, N. L., Landenberger, R. E., & McGraw, J. B. (2007). Germination and early growth of *Ailanthus* and tulip poplar in three levels of forest disturbance. *Biological Invasions*, *9*, 197-211.

Kowarik, I. (2010). *Biologische Invasionen*. Verlag Eugen Ulmer.

Kowarik, I., & Säumel, I. (2007). Biological flora of central Europe: *Ailanthus altissima* (Mill.) swingle. *Perspectives in Plant Ecology, Evolution and Systematics*, *8*(4), 207-237.

Kreitman, D., Keena, M. A., Nielsen, A. L., & Hamilton, G. (2021). Effects of temperature on development and survival of nymphal Lycorma delicatula (Hemiptera: Fulgoridae). *Environmental Entomology*, *50*(1), 183-191.

Lamarque, L. J., Delzon, S., & Lortie, C. J. (2011). Tree invasions: a comparative test of the dominant hypotheses and functional traits. *Biological invasions*, *13*, 1969-1989.

Landenberger, R. E., Kota, N. L., & McGraw, J. B. (2007). Seed dispersal of the non-native invasive tree *Ailanthus altissima* into contrasting environments. *Plant Ecology*, *192*, 55-70.

Li, X., Li, Y., Ma, S., Zhao, Q., Wu, J., Duan, L., ... & Wang, S. (2021). Traditional uses, phytochemistry, and pharmacology of *Ailanthus altissima* (Mill.) Swingle bark: A comprehensive review. *Journal of Ethnopharmacology*, *275*, 114121.

Lorenzo, P., & Morais, M. C. (2023). Strategies for the management of aggressive invasive plant species. *Plants*, *12*(13), 2482.

Marini, F., Profeta, E., Vidović, B., Petanović, R., de Lillo, E., Weyl, P., ... & Cristofaro, M. (2021). Field assessment of the host range of *Aculus mosoniensis* (Acari: Eriophyidae), a biological control agent of the tree of heaven (*Ailanthus altissima*). *Insects*, *12*(7), 637.

Maschek, O., & Halmschlager, E. (2017). Natural distribution of Verticillium wilt on invasive *Ailanthus altissima* in eastern Austria and its potential for biocontrol. *Forest Pathology*, *47*(5), e12356.

Mehrhoff, L. J. (1998). The biology of plant invasiveness. *New England Wild Flower*, *2*, 8-10.

Meloche, C., & Murphy, S.D. (2006). *"Managing tree-of-heaven (Ailanthus altissima) in parks and urban settings: An integrated approach", Urban Forestry & Urban Greening.*

Miller, J. H., Manning, S. T., & Enloe, S. F. (2013). A management guide for invasive plants in southern forests. *Gen. Tech. Rep. SRS–131. Asheville, NC: US Department of Agriculture Forest Service, Southern Research Station. 120 p.*, *131*, 1-120.

Nowak, D. J., & Crane, D. E. (2002). Carbon storage and sequestration by urban trees in the USA. *Environmental pollution*, *116*(3), 381-389.

Okunade, A. L., Bikoff, R. E., Casper, S. J., Oksman, A., Goldberg, D. E., & Lewis, W. H. (2003). Antiplasmodial activity of extracts and quassinoids isolated from seedlings of *Ailanthus altissima* (Simaroubaceae). *Phytotherapy Research*, *17*(6), 675-677.

Pile Knapp, L. S., Rebbeck, J., Hutchinson, T., Fraser, J., & Pinchot, C. C. (2022). Controlling an invasive tree with a native fungus: inoculating *Ailanthus altissima* (Tree-of-Heaven) with *Verticillium nonalfalfae* in highly disturbed Appalachian forests of Ohio. *Journal of Forestry*, *120*(5), 558-574.

Planchuelo, G., Catalán, P., & Delgado, J. A. (2016). Gone with the wind and the stream: Dispersal in the invasive species *Ailanthus altissima*. *Acta Oecologica*, *73*, 31-37.

Rebbeck, J., Malone, M. A., Short, D. P. G., Kasson, M. T., O'Neal, E. S., & Davis, D. D. (2013). First report of Verticillium wilt caused by Verticillium nonalfalfae on tree-of-heaven (*Ailanthus altissima*) in Ohio. *Plant disease*, *97*(7), 999-999.

Güney Sarıtaş, A., & Gürbüz, R. (2024). Effects of Hot Water Obtained by Solar Energy on the Weeds *Convolvulus arvensis* L., Setaria viridis (L.) P. Beauv. and *Amaranthus retroflexus* L. *Yuzuncu Yıl University Journal of Agricultural Sciences*, *34*(2), 346-353.

Sladonja, B., Sušek, M., & Guillermic, J. (2015). Review on invasive tree of heaven (*Ailanthus altissima* (Mill.) Swingle) conflicting values: assessment of its ecosystem services and potential biological threat. *Environmental management*, *56*, 1009-1034.

Soler, J., & Izquierdo, J. (2024). The invasive *Ailanthus altissima*: A biology, ecology, and control review. *Plants*, *13*(7), 931.

Taşkın, R., Gürbüz, R., & Alptekin, H. (2025). The Frequency and Densıty of Weeds in Peanut (Arachis hypogaea L.) Fıelds of Adana Provınce, Türkiye. Research in Agricultural Sciences, 56(2), 112-121.

Tülek, C., Gürbüz, R., & Alptekin, H. (2022). Organik malç materyallerinin domates (Solanum lycopersicum L.)'te yabancı ot kontrolüne etkisi. Journal of Agriculture, 5(2), 86-101.

Uludağ, A., & Önen, H. (2015). *Ailanthus altissima*. H. Önen (Ed.), *Türkiye istilacı bitkiler kataloğu* (ss. 148-155). Gıda, Tarım ve Hayvancılık Bakanlığı.

USDA, (2025). United States Department of Agriculture (USDA). 2025. Tree-of-heaven *(Ailanthus altissima)*. https://www.invasivespeciesinfo.gov/terrestrial/plants/tree-heaven (Accessed October 13, 2025).

Venegas, T. J., & Pérez, P. C. (2009). Análisis y optimización de técnicas de eliminación de especies vegetales invasoras en medios forestales de Andalucía. In *Proceedings of the V Congreso Forestal Español, Ávila, Spain* (pp. 21-25).

Vilà, M., Basnou, C., Pyšek, P., Josefsson, M., Genovesi, P., Gollasch, S., ... & DAISIE partners. (2010). How well do we understand the impacts of alien species on ecosystem services? A pan-European, cross-taxa assessment. *Frontiers in Ecology and the Environment*, *8*(3), 135-144.

Vilà, M., Espinar, J. L., Hejda, M., Hulme, P. E., Jarošík, V., Maron, J. L., ... & Pyšek, P. (2011). Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. *Ecology letters*, *14*(7), 702-708.

Vilà, M., Tessier, M., Suehs, C. M., Brundu, G., Carta, L., Galanidis, A., ... & Hulme, P. E. (2006). Local and regional assessments of the impacts of plant invaders on vegetation structure and soil properties of Mediterranean islands. *Journal of Biogeography*, *33*(5), 853-861.

Voutos, Y., Godsil, N., Sotiropoulou, A., Mylonas, P., Bouchagier, P., Exarchos, T., ... & Kabassi, K. (2021). Capturing and Evaluating the Effects of the Expansive Species *Ailanthus altissima* on Agro-Ecosystems on the Ionian Islands. *Engineering Proceedings*, *9*(1), 19.

Wang, Y., Wang, W. J., Su, C., Zhang, D. M., Xu, L. P., He, R. R., ... & Ye, W. C. (2013). Cytotoxic quassinoids from *Ailanthus altissima*. *Bioorganic & medicinal chemistry letters*, *23*(3), 654-657.

Yang, J., Tang, L., Guan, Y.-L. & Sun, W.-B. (2012). Genetic diversity of an alien invasive plant mexican sunflower (*Tithonia diversifolia*) in China. Weed Science, 60(4), 552-557.

Young, C. C., Bell, J. C., & Morrison, L. W. (2020). Long-term treatment leads to reduction of tree-of-heaven (*Ailanthus altissima*) populations in the Buffalo National River. *Invasive Plant Science and Management*, *13*(4), 276-281.