Biological and Ecological Characteristics of *Ailanthus Altissima (Mill)*

Aydin Yahyayev[1] and **Turan Huseynov**[1]

[1]School of Advanced Technologies and Innovation Engineering, Department of Ecology and Environmental Sciences, Western Caspian University, Baku, AZ1072, Azerbaijan.

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Abstract

In a lot of western countries *Ailanthus Altissima* is considered an invasive tree species. *Ailanthus* has gained this reputation due to its rapid growth and ability to crowd out native trees. It produces a large amount of seeds and these seeds spread easily and develop deep, strong root system after germination. This type of root system makes it difficult to remove the plant during mechanical control methods. *Ailanthus* is also known for its abilty to produce special allelopathic substances. They slow down the growth rate of other tree species and make the minerals less accessible for them. This species is common in most urban places. They can be found on roadsides, near walls, old buildings, gardens and its roots can damage paving, walls and other infrastructure. Numerous studies have investigated its biology, dispersal mechanisms, control methods including mechanical, chemical and biological. The purpose of this article is to provide overview of some of the studies summarising resear methods, laboratory analyses, field trials highlighting key findings regarding growth patterns, environmental impacts and control effectiveness. This review highlights the ecological, infrastructural, and other challenges associated with *Ailanthus* as well as ongoing research aimed at reducing its spread and understanding its behaviour under different environmental conditions.

Keywords: *Ailanthus Altissima*, seed dispersal, invasive species, impact in urban environment, management strategies, control methods, ecological research

1.Introduction

The tree of heaven (*Ailanthus altissima, Mill*) is a tree that originates from northern and central China and is found on every continent except Antarctica. Its rapid growth and ability to thrive in difficult conditions with minimal care have made it a relatively popular garden plant in the East. Its natural habitat is mainly mountainous and hilly regions, but also it can be found in coastal plains. The *ailanthus* tree produces several hundred thousand seeds per year (Thomson, 2011), and these light, winged seeds can be transported over long distances from the parent plant (Planchuelo et al., 2016). It grows vigorously and forms dense clonal stands that can displace native vegetation (Hunter, 2000). The *ailanthus* tree's ability to tolerate poor soils and air pollution makes it a frequent coloniser of urban areas (Ferret, 1974; Mergen, 1959). Roadsides and footpaths are excellent migration routes for this tree.

Ecology – *Ailanthus altissima* is an extremely competitive and fast-growing tree, whose young shoots can reach a height of 3 to 4.5 m. Once established, it can displace native vegetation and form dense clonal stands. It has been cultivated throughout Absheron since ancient times and is found in the Kur-Araz, Samur-Shabran, Lankaran, Alazano-Ayracha regions, as well as in the plains of Kura, Nakhchivan, Ismayilli and on the coast of the Caspian Sea. Main areas of distribution: Baku, Shamakhi, Agsu, Kurdamir, Goychay, Agdash, Ganja, Yevlakh, Mingechevar, Barda, Agdam, Salyan, Sabirabad, Beylagan, Nakhchivan (Mamedov et al., 2014).

Although the tree of heaven is more common in urban areas, it is invasive in agricultural land and natural areas and poses an ecological threat. The tree of heaven is a prolific seed producer, and its seeds can be spread by wind, water, birds, agricultural equipment and road vehicles. However, most new plants in a given area usually develop from root suckers. When the trunk is felled, new shoots can form on the lateral roots at a distance of 15 to 27 metres from the parent tree. After germination, the seedlings can form deep roots within three months, allowing the plant to grow rapidly and compete with native species for light and space. *Ailanthus* grows in full sun but also tolerates shade. In addition, this plant produces an allelopathic substance that inhibits the growth of other plants in its vicinity.

Biology – *Ailanthus* can be characterised by the following features:

• It is a small to medium-sized tree that can reach a height of over 25 m. Generally, its height reaches 20-25 m.

• The leaves are lanceolate and have 1-3 teeth on each side of the leaf. When crushed, the leaves give off an unpleasant odour.

• The bark is smooth, grey and cracks with age.

• The young branches are green then turn into light brown with age. Aged branches turn into gray

• It flowers in July and August. The greenish-yellow flower has 5 sepals and 5 petals.

• The seeds are surrounded by a papery, wing-like shell.

• The fruits are slightly twisted, curved. It has a reddish color.

• Diseases do not cause serious problems, with the exception of *Verticillium wilt*.

• *Ailanthus* is generally characterised as a shade-intolerant tree and does not respond well to reduced light intensity, but there is evidence that *Ailanthus* is characterized as a shade-tolerant species in various regions of the world.

• Studies have also shown that an extract made from the leaves of *ailanthus* (ailonthon) has a negative effect on 35 species of gymnosperms and 11 species of angiosperms.

2.Key findings of studies published between 2000 and 2025

Ailanthus altissima's rapid spread, great adaptability, and ecological effects have attracted more scientific attention over the past few decades. Its biological characteristics, reproductive strategies, and ability to compete in both natural and man-made environments have been studied by researchers from various geographical areas. Special attention has been given to its invasive behaviour aswell as to its management and control. The results of these investigations serve as the foundation for comprehending the ecological significance of the species and for creating efficient management plans. This section summarizes key scientific studies and highlights the most important findings related to *Ailanthus altissima*:

Hunter, J. (2000) His results researching Ailanthus.

Location: California, USA.

Method: Starting with past studies, Hunter (2000) pieced together insights about Ailanthus altissima through narrative analysis. Rather than running new tests, he examined published papers, on-the-ground notes, official records, and judgments from specialists. One by one, these materials helped shape a layered understanding of the plant. From ecology work to trials measuring control success, each reference contributed meaningfully. What stood out was how features like growth patterns, seed spread methods, and intervention results varied by environment. Through careful linking of findings, differences across ecosystems came into view.

Result: One finding stood out clearly: mechanical removal alone fails often, due to the plant's tendency to grow new shoots from underground roots. Though it seems logical, doing cuts again and again sometimes boosted the number of stems instead of reducing them. On the other hand, using chemicals - particularly applying herbicides right after cutting stumps or near the lower stem - reduced sprouting far better. Success improved sharply once physical removal was paired with chemical treatment. What mattered just as much was spotting infestations early and acting fast. Depending only on chopping proved unwise throughout the trials.

Research on Ailanthus altissima seedling growth in gaps under the forest canopy.

Location: Hudson Valley, New York, USA.

Method: The authors conducted an observational field study in a centuries-old coniferous and deciduous forest, focusing on *Ailanthus altissima* seedlings that had emerged in naturally occurring gaps in the canopy. They measured the height of the seedlings, stem diameter and radial growth rates over time and quantified light availability in the gaps and under the canopy. For comparison purposes, the same measurement protocols were used for native tree species growing in the same gaps.

Result: *Ailanthus* seedlings grew significantly faster than the competing native species in the gaps in the canopy. Growth rates in height and radius were significantly higher with greater light exposure. The species showed rapid growth after the clearing was created, enabling it to quickly reach the forest canopy. The recruitment of new seedlings was closely related to the disturbances caused by the clearings. These characteristics confirm the classification of the species as invasive and clearing-dependent. Even old forests are vulnerable after disturbances. (Knapp, L. B., & Canham, C. D. 2000).

DiTomasso and Kaiser (2001) investigated the use of herbicides on *Ailanthus* trunk.

Location: Yolo County, California, USA

***Method*:** The authors conducted a field trial with herbicides in which three systemic herbicides (imazapyr, triclopyr and glyphosate) were applied to the trunk using different application methods: trunk cut, stump injection, treatment at the base of the trunk and the "hack-and-squirt" method on trees of different sizes. The effects of the treatment were monitored by regular assessments of survival, regrowth and the condition of the tree crowns during the growing seasons.

Result: Treatments at the base of the trunk and trunk pruning with imazapyr or triclopyr achieved the best control, often exceeding 90-95% mortality. Injections into the trunk with imazapyr and glyphosate also resulted in high control with minimal regrowth. At the same time, injection into the tree stump and manual pruning alone did not suppress growth. The untreated trees quickly sprouted again. The study confirmed that the choice of herbicide and the method of application significantly influence the effectiveness of control. Chemical treatment of the trunks is recommended for long-term control.

Birch and Zedaker, (2003) evaluated herbicide treatments on *Ailanthus* trees of varying sizes.

Location: Virginia, USA.

Method: The researchers conducted a field trial on established ailanthus plantations, applying eight treatments of low-dose herbicides to the base of the trunks. The treatments were compared with manual pruning of the trees as a control. The applications were carried out on trees of varying sizes, and mortality, regrowth intensity and vegetation recovery over time were recorded during follow-up observations.

Result: Herbicide treatments led to high mortality in *Ailanthus altissima*, with very little regrowth observed. The combined use of Garlon 4 and Tordon K was especially effective, as it not only killed the treated trees but also limited regrowth from the root system. By contrast, manual pruning on its own triggered strong regrowth from both stumps and roots. In sites where pruning was carried out only once, stem density increased over time, which ultimately accelerated the spread of the species. Overall, the findings indicated that mechanical removal without herbicide application can be counterproductive, while integrated chemical control remains the most dependable management approach.

Trifilo et al. (2004) tested drought resistance of *Ailanthus* tree.

***Location*:** Italy.

Method: Over 13 weeks, potted *Ailanthus altissima* seedlings experienced four distinct irrigation levels to generate varying soil moisture states. Leaf water status and stomatal function were tracked regularly during this time, while root and shoot hydraulic performance was assessed via high-pressure flow measurements. Instead of relying solely on physiological data, researchers also analyzed cross-sections of root xylem under magnification to detect structural shifts due to limited water availability. When drought-exposed specimens showed altered traits, these findings stood in contrast to individuals receiving consistent hydration. Patterns in transport efficiency often trailed behind visible tissue modifications, suggesting delayed functional consequences. Though some adjustments appeared early, others emerged only after prolonged exposure to dry conditions. Such differences highlighted how internal structure and whole-plant physiology respond at separate rates.

Result: Even when drought was intense, the young plants kept their leaf moisture fairly steady. Because stomata shut early, less water escaped through evaporation. While that happened, roots carried far less water due to falling conductivity, slowing supply inward. As a result, vital tissues avoided breakdown from dehydration. These combined adjustments reveal a method of saving water effectively - this likely supports why the plant thrives and survives where rainfall is low.

Kota (2005) investigated seed germination of *Ailanthus* and its differences from Liriodendron tulipifera.

Location: USA.

Method: Out in the eastern U.S., Kota looked at how *Ailanthus altissima* stacks up against the local Liriodendron tulipifera near woods borders and open spots. Instead of just observing nature, a mix of on-site checks and hands-on tests shaped the core of the work. Samaras, those winged seeds that ride the wind, got gathered farther and farther from adult trees - this helped sketch out how far they typically travel. From there, patterns in seed spread began to take shape using the collected data points. When young plants took root, their start in life was tracked carefully after deliberate planting across zones marked by varying disruption levels. Germination outcomes appeared alongside survival numbers, both recorded repeatedly as weeks passed. Over months, increases in plant mass also entered the picture as part of growth tracking. Because both species faced identical surroundings during testing, contrasts emerged more clearly. One thing became visible - the invasive type often behaved differently than its native counterpart when placed side by side.

Result: When it dried out, *Ailanthus altissima* kept its leaves hydrated by shutting stomata fast. Because of stress, roots lost most of their ability to move water - this slowed loss. Instead of growing tall, the plant put energy into staying alive. Unlike local trees, Ailanthus changed how it functioned depending on surroundings. With these traits, young plants lasted longer when rain varied - and showed why they thrive where ecosystems are broken.

Another study aimed to investigate control methods of *Ailanthus* trees produced following results

Location: Rondo Provincial Park, Ontario, Canada.

Method: The authors evaluated various methods of controlling ailanthus in the park using a range of treatments, including manual removal with mulching, cutting the stem with glyphosate treatment, cutting the stem only, and the EZJect Capsule injection system with glyphosate. The treatments were carried out on both young and mature specimens in different areas of the park. After treatment, monitoring was carried out over several seasons to record tree mortality and regrowth responses. The feasibility of management in a protected area was also assessed.

Result: Treatment by cutting the stem with glyphosate resulted in maximum control of young shoots. The EZJect system effectively destroyed mature fruit trees. Manual digging and mulching was moderately successful for small plants. Only cutting the stumps led to increased regrowth and infestation. Chemical treatments were necessary for long-term control. The study emphasised the importance of adapting methods to plant size and site conditions. (Meloche, C., & Murphy, S. D. 2006).

Ding et al. (2006) researched biological control of *Ailanthus*

Location: China, Europe and North America.

Method: The authors reviewed the literature on the natural enemies of *Ailanthus altissima* in its native and introduced ranges and collected data on phytophagous insects, pathogens and other antagonists of the species. The review catalogued phytophagous insects, fungi and potyviruses recorded in China, Europe and North America. The authors assessed host specificity and the potential effectiveness of biological control by comparing documented interactions and the degree of damage. Potential risks to non-target species were also considered when assessing suitability for classical biological control programmes.

Results: Several insects, including *Eucryptorrhynchus brandti* and *E. chinensis*, showed high host specificity. Fungal diseases and vascular pathogens also showed significant damage potential. Some organisms were excluded due to the risks to non-target species. The review identified promising candidates for further testing. Biological control was considered a complementary strategy with mandatory risk assessment.

Another research on chemical control of *Ailanthus* trees and their results

Location: USA.

Method: The authors conducted a field trial with herbicides on stems of *Ailanthus altissima* in California, using three systemic herbicides – imazapyr, triclopyr and glyphosate – with four methods of stem application: stem cutting, injection into the stump, injection into the stem and treatment at the base of the stem. These methods were applied to both individual stems and groups of individuals to evaluate their effectiveness. Manual pruning and untreated plants served as controls. After treatment, mortality and regrowth were monitored to compare the effectiveness of the different combinations of herbicides and methods.

Result: Cutting through the main stem and its base using imazapyr or triclopyr led to strong suppression - more than 90% success across trials. Trunk injections with either imazapyr or glyphosate brought similar outcomes, killing most trees while limiting sprouting afterward. When treatment shifted solely to injecting stumps, results fell sharply. Removing growth by hand, absent any chemical follow-up, triggered rapid rebounding shoots instead. The findings showed how key both the specific herbicide used and its delivery approach really are. For lasting effectiveness, applying chemicals directly to the trunk tends to work best. (DiTomaso, J. M., & Kyser, G. B. 2007).

Landenberger, et al. (2007) studied *Ailanthus altissima* seed movement.

Location: America, West Virginia

Method: Out into the open, a field investigation tracked how *Ailanthus altissima* seeds move through landscapes in West Virginia - places like farmland, untouched woods, and spots where trees had been partly cut. Along straight lines stretching 100 meters from parent trees, researchers gathered falling seeds at fixed points throughout the release season to map their spread. Instead of focusing only on distance, they paid attention to things like plant density, wind paths, and traits of the seeds themselves. Rather than treating each factor alone, interactions between them emerged when analyzed via three-way ANOVA and fitted regression equations. From edge to core, variation in seed deposition revealed strong ties to both proximity and setting.

Results: Wind carried seeds across every kind of landscape, often beyond one hundred meters. Where they landed depended heavily on which way the air moved and how plants were arranged on the ground. Even though some seeds were bigger than others, both kinds covered roughly the same ground. Movement happened mostly during the first part of the growing period. Where tree lines meet open ground, seeds move farther into nearby ecosystems. These results, taken together, clarify how quickly *Ailanthus altissima* expands across broken-up terrain.

Another study investigating the effectiveness of herbicide treatments on *Ailanthus* yielded these results.

Location: America

Method: Starting with tree injections, Lewis and McCarthy used imazapyr to target *Ailanthus altissima* in Ohio woodlands. Close inspection followed around each treated trunk, focusing on plants within three meters for signs of off-target damage. Death among injected trees and nearby stems was logged weekly across more than a year. Trunk size mattered; it shaped how far harm spread beyond the main target. Distance from the treated stem helped clarify where unintended losses occurred. Alongside physical measurements, hidden connections - like linked roots or soilborne chemical flows - were weighed as possible transmission routes. Observations ran continuously, capturing delayed responses just as clearly as immediate ones. (Lewis, K., & McCarthy, B. 2007).

Result: Every *Ailanthus* that received treatment ended up dead. Still, nearby trunks suffered too - about 17.5% perished, even some from different species. As separation grew from the treated trees, chance of harm dropped noticeably. Tiny stems showed higher sensitivity compared to bulky ones; where plants crowded together or plots stretched wide, chemical movement reached farther. Taken together, these outcomes suggest careful planning matters when applying injected herbicides among diverse woodlands.

Rebbek, et al. (2013) studied effect of *Verticillium nonalfalfae* on *Ailanthus Altissima*.

Location: USA

Method: Stem specimens came from sick *Ailanthus altissima* trees spotted across southern Ohio during joint field and lab work. Instead of skipping steps, researchers cleaned sample surfaces before placing them on plum extract agar to grow fungi. Colonies thought to be relevant emerged under scrutiny involving spore-bearing structures plus genetic methods. Rather than relying only on appearance, scientists pulled out DNA and sequenced three gene regions - EF 1α, GPD, TS - for deeper analysis. Once processed, those results entered BLAST queries matching them against known entries in databases. When testing harmful potential, young plants received doses of spore mixtures followed by close watch for illness signs or death. What began as visible decline in forests ended in controlled proof linking fungus to disease.

Result: Every isolate turned out to be *Verticillium nonalfalfae*. Seedlings that received the inoculation began showing serious wilting before death followed, pointing clearly to intense pathogenic strength alongside narrow host range. Notably, this work marked the initial verified case of V. nonalfalfae within Ohio's borders, joining two other American states with recorded instances. Taken together, evidence suggests this microbe could serve effectively in managing Ailanthus altissima populations through natural means.

Another research showing effect and damage of *Verticillium nonalfalfae* on *Ailanthus Altissima* and its results.

Location: Virginia, North Carolina, South Carolina, United States.

Method: The researchers conducted a large-scale regional field survey of ailanthus sites in the southeastern United States (Virginia, North Carolina, and South Carolina), covering approximately 26,500 km of roads and forests. They visually examined the trees for symptoms of *Verticillium* wilt and took samples from the trunk and xylem of symptomatic trees to isolate the pathogen and cultivate it on selective media. In greenhouse trials, healthy seedlings were inoculated with isolates to assess the virulence and severity of the disease. Incidence data were recorded and compared between study years to assess changes in distribution and frequency.

Result: Areas infected with *Ailanthus* were identified at six sites in the mountains of Virginia. All isolates resulted in 100 per cent mortality of infected seedlings. The incidence of the disease increased between 2011 and 2012. The pathogen showed high virulence and stability between isolates. The results indicate natural spread in the region. The study confirmed the potential of the pathogen as a biological control agent. (Snayder et al. 2012/2014).

Cabra-Rivas et al. (2014) studied *Ailanthus altissima* seedling distribution along a river.

Location: Spain.

Method: Through a field study, researchers examined how water carries seeds of Ailanthus altissima by introducing samaras into two distinct 100-meter stretches of river - one nearly natural, the other altered in form. Instead of simultaneous measurements, they monitored fruit motion and settling across 90 minutes via sight checks paired with periodic collection. While tracking progress downstream, they also measured physical features like aquatic plants and dead wood at both locations. Rather than assuming uniform behavior, they assessed differences in travel range and trapping frequency between sites. Because structural variation affected outcomes, comparisons focused on how habitat layout shapes floating seed movement. Although brief in duration, the observation window captured meaningful shifts in distribution patterns.

Results: Fewer fruits stayed in place where the river showed signs of damage - about one-fifth compared to healthier stretches. Because plants were sparser, drifting fruits moved greater distances before stopping. Instead of flowing freely, many seeds got caught when water plants slowed their path. With fewer obstacles present, floating fruit traveled longer routes more easily. As a result, broken habitats made it likelier for seeds to reach faraway spots by water. In these areas, plant life once acted like nets; now that protection is weaker. Dispersal patterns shifted noticeably wherever human impact altered natural conditions.

Knusel et al. (2017) came into following conclusions studying shade tolerance of *Ailanthus.*

Location: Switzerland.

Method: Using hemispheric photos, researchers measured how much light reached 204 young tree-of-heaven saplings, aged one to seven, growing beneath chestnut trees at six Swiss locations. Rather than relying on estimates, they directly linked each plant's growth and survival to actual canopy gaps above it. Though some originated from seeds, others sprouted from roots - both types tracked over time. Instead of assuming uniform behavior, scientists compared performance across brightness levels found in real woodland settings. Following several seasons, individual output patterns helped redefine assumptions about how well this species copes in dim environments. Because field conditions varied naturally, conclusions reflect realistic understory scenarios. Notably, results challenge earlier lab-based generalizations about its low-light limits.

Results: Survival among young *Ailanthus* specimens occurred even when light was limited - something earlier estimates did not expect. Not only seed-originated individuals but also those from vegetative propagation handled shaded conditions fairly well. Even though thick overhead foliage slowed development, the plants persisted without dying off. This evidence questions long-held views about the plant needing abundant sunlight. Where tree cover forms a tight roof above ground and parent trees are nearby, forests might face higher risks of infestation because shade adaptability strengthens how aggressively the species spreads.

Petruzzellis et al. (2019) studied differences between *Ailanthus altissima* and *Fraxinus ornus*

Location: Italy.

Method: The study conducted a comparative analysis of functional traits between *Ailanthus altissima* and *Fraxinus ornus,* which is native to Italy. Leaf and wood properties related to water transport (hydraulics) and carbon investment were measured, including vessel anatomy, leaf area, and wood density. Hydraulic efficiency and responses to drought were assessed under different light conditions using standardised physiological measurements. Phenotypic plasticity was assessed under different conditions, and carbon investment indices were evaluated to understand the differences in structural investment between species.

Results: *Ailanthus* showed higher hydraulic efficiency than *Fraxinus ornus.* The species showed higher phenotypic plasticity in response to light changes but had lower drought tolerance and lower structural investment. Rapid resource utilisation favoured rapid growth. These traits favour invasion under productive conditions. The results show a trade-off between efficiency and resilience.

Bubichi, et al. (2020) researched effect of *Aleurocanthus spiniferus* on *Ailanthus Altissima*

Location: Bari, Italy.

Method: A field study was conducted in Bari, southern Italy, to assess the infestation of *Ailanthus altissima* by *Aleurocanthus spiniferus*. The insects (adults and larvae) were collected from various trees and morphologically identified under a stereomicroscope. Microbiome and microtranscriptome analyses were performed using deep sequencing of small RNAs (sRNA Seq), and bioanalytical tools were used to analyse RNA profiles, including bacterial endosymbionts and microRNAs. Damage to the host, infection frequency and spatial distribution were recorded to assess insect-host interactions.

Result: *Ailanthus altissima* was regularly infested by *A. spiniferus*. The infections did not pose a threat to the survival of the host. The insect harboured several bacterial endosymbionts. Several known and new microRNAs were identified. The species has been shown to adapt to the host. Although the insect is not lethal, it can affect the physiology of the plant.

Pepe et al. (2022) came to these conclusions while researching the water resistance of *Ailanthus altissima*.

Location: Italy (Mediterranean region)

Method: The authors conducted a controlled water stress experiment on seedlings of *Ailanthus altissima, Phytolacca americana* and *Robinia pseudoacacia* under Mediterranean conditions to compare the responses of the species. The plants were exposed to predetermined drought conditions, and measurements were taken throughout the stress period. The physiological characteristics of the leaves (gas exchange, water status of the leaves), morphological characteristics (leaf mass per unit area – LMA, leaf area) and indicators of water use strategy were recorded. The data were analysed using a two-way ANOVA and correlation analysis to assess the influence of species and duration of stress on physiological and morphological responses.

Result: *Ailanthus* showed greater resistance to water stress compared to other species. Leaf mass per unit area increased under stress conditions. Tolerance was maintained despite the water use strategy. Physiological plasticity favoured survival. These characteristics improve competitiveness in the Mediterranean climate and demonstrate adaptation to fluctuations in water availability.

Results of Research on the Occurrence and Molecular Characterization of *Aculus mosoniensis* associated with *Ailanthus altissima*

Location: France

Method: Field surveys mapped *Ailanthus altissima* stands throughout several French regions, targeting possible eriophyid mite associations. From every location, researchers gathered leaves from numerous host trees following a structured sampling approach. Specimens were extracted carefully before being inspected using optical microscopy. Key physical traits - especially those useful for classification - received particular attention during analysis. Instead of relying solely on appearance, scientists turned to DNA methods for verification. Individual mites had their mitochondrial COI region analyzed through sequencing techniques. Genetic data helped pin down exact species while also revealing variation within sampled populations. From these sequences, scientists looked at variation within species and differences among haplotypes, while mapping where *Aculus mosoniensis* occurs across the landscape to understand how widely it has spread. Host preferences formed another part of the investigation, along with an assessment of whether this mite might serve a role in managing plant pests naturally.

Results: Found only *Aculus mosoniensis* among the collected mites. For the first time ever, presence in France gets solid confirmation. Variation within the species shows up clearly through DNA testing. Movement across European regions appears ongoing, driven by active spread. Favoring certain hosts may make this organism useful for managing pests naturally. Research into its environmental interactions should continue. (Kashefi, et al. 2022).

3.Result

A look at earlier research highlights Ailanthus altissima (Mill.), a tree originally from Across northern and central regions of China, this tree species now ranks among the toughest non-native plants to manage in numerous areas. Though initially developed for uses like medicine, its role has since spread across the globe. Now found well outside where it first grew, ornamental planting carried this species across new territories. The reason behind its widespread invasion largely ties to its thriving quickly under tough conditions marks its life cycle, while abundant seeds ensure wide spread. Harsh climates rarely slow it down thanks to built-in resilience traits. Success in extreme settings comes not just from speed but also from reproductive strength. Survival hinges on endurance paired with prolific output across difficult landscapes. A tree's ability to thrive often depends on how it reproduces. What makes *A. altissima* particularly successful lies in the way it multiplies. Spreading quickly becomes possible when new growth emerges frequently. Its method of reproduction gives it an edge over others. Because offspring develop rapidly, colonies expand without delay. This pattern allows dense stands to form across varied environments. Meanwhile, this plant moves quickly by sending out roots that travel along the ground, Besides forming thick clusters originating from a single source, this type of growth tends to overshadow local flora. Competition gradually reduces the presence of indigenous plants. Shrinking species variety while shifting how nearby environments are built and operate. Because of studies on how organisms function and their environments, scientists understand better what allows this species to settle successfully. Thriving across diverse environments has been possible due to adaptability. Research into dry conditions reveals that *A. altissima* relies on multiple strategies to conserve water, such as precise control of when stomata open, movement of water through roots faces constraints. Survival during dry spells becomes possible because of these adjustments. Severe water scarcity could threaten numerous indigenous species, possibly leading to their decline. Besides this, studies shows *A. altissima* can adapt easily. Though thriving in open areas, where conditions are disrupted, survival remains possible even when light levels drop below full sun exposure. This flexibility allows the species to invade both open environments and more closed forest ecosystems. Studies on seed dispersal confirm the species' ability to effectively colonise fragmented landscapes, river corridors and human-altered environments such as roadsides and urban areas.

Management-oriented studies clearly show that mechanical control methods alone are largely ineffective and often counterproductive, as cutting stimulates active regrowth and increases population density. In contrast, chemical methods – in particular the treatment of stumps, application to the bark and injection of chemicals such as imazapyr and triclopyr into the trunk – have repeatedly shown high mortality rates and long-term growth suppression. However, several studies also point out that the use of herbicides is not without risks. In particular, they warn about possible negative effects on non-target species during herbicide transport and stress the importance of careful, well-controlled application, especially in mixed stands. Case studies from protected and conservation areas further indicate that successful management of *Ailanthus altissima* cannot rely on a single method. Instead, effective control usually depends on integrated approaches that are adapted to local ecological conditions.

In recent years, biological control has received increasing attention as a potential long-term solution. Scientists are now studying a fungus called *Verticillium nonalfalfae,* with attention also given to finding success in targeted insect and mite hosts has emerged from recent studies. Cases of naturally occurring infestations agents showing strong pathogenic effects might help limit *A. altissima* populations. Their impact appears significant under certain conditions. This potential arises naturally during infection cycles. Effectiveness varies across environments. Still, results point toward meaningful suppression in some cases. Continued observation may clarify long-term outcomes over time, shifts in population patterns emerge. The spread of Ailanthus altissima emerges clearly when patterns are examined across different regions. It stems from multiple elements, such as strong breeding rates, flexible body functions allow survival under shifting conditions. Despite narrow limits in some species, these organisms handle wide changes well. What sets them apart is how easily they adjust internal processes when surroundings shift. Their capacity to thrive amid disruption stands out clearly advantage of ecosystem disturbances. Effective control therefore requires an integrated approach combining chemical, mechanical and possibly biological methods, as well as early detection and prevention at the landscape level. Without continuous and scientifically sound measures, *A. altissima* will continue to expand its range and have a significant impact on the ecology and management of both natural and urban ecosystems.

Several studies have investigated methods for controlling Ailanthus altissima. DiTomasso (2001) and Kaiser (2007) tested herbicides, including imazapyr, triclopyr and glyphosate, which were applied through cuts in the trunk, injections into the trunk, injections into the stump and treatments at the base of the trunk, while manual pruning and untreated plants served as controls. Burch and Zedaker (2003) applied low-volume herbicide treatments at the base of the trunk and compared them with manual cutting to evaluate their effectiveness in terms of mortality, regrowth and stand recovery. Melosh and Murphy (2006) tested trunk cutting with glyphosate, manual removal with mulching, and the EZJect Capsule injection system, observing both young and mature trees. Across the reviewed studies, herbicide treatments were consistently found to be more effective than pruning alone, particularly when they were combined with mechanical removal. In contrast, pruning by itself often resulted in regrowth, which in some cases continued over several growing seasons. What emerges here points to a need - more often than not - for combined strategies when aiming at lasting management outcomes.

Ailanthus altissima has drawn scientific attention due to its bodily reactions under stress, yet findings remain scattered across different experiments because methods differ too widely to allow clear comparisons between results seen so far focus on how well it withstands dry conditions. Studies by Trifilò in 2004 and later by Pepe in 2022 tested ailanthus under such stress. Fresh young plants faced limited moisture, their responses measured through indicators like pressure within leaves and tiny openings on surfaces. Leaf tension dropped when supply tightened, showing how each specimen managed available resources differently. Some held steady longer, others reacted quickly as conditions shifted. Observations tracked shifts over time, noting differences in behavior under strain. Each data point reflected a moment of adjustment during exposure. Hydraulic traits, alongside measures like conductance, shape how leaves manage water. Leaf mass per unit area emerges as a key factor when examining gas exchange dynamics. Another investigation explores similar patterns across species. Petruzzelli (2019) examined how plants function by analyzing water movement through leaves alongside wood structure. Under varying light, traits shift alongside carbon allocation while flexibility in form adjusts accordingly. Later work on shade tolerance came from Knyzel and team in 2017, examining how trees manage light through crown structure, by capturing images across the hemisphere, researchers tracked how seedlings developed and stayed alive. In combination, these studies demonstrate that *Ailanthus altissima* exhibits a high degree of physiological flexibility helps sustain moisture levels when stressed, also supporting survival where light is limited. This fuels quick development while improving chances of survival.Focusing on how species spread, some studies explore movement and settlement processes. Take Knapp, whose work illustrates this approach, Kenham (2000), meanwhile, monitored how young plants developed and established themselves within naturally occurring openings in the tree cover through systematic observation. Height shifts, along with diameter changes, occurred alongside fluctuating radial growth speeds due to shifting light conditions through the years. Findings showed what stands out is how swiftly the species takes advantage of improved light levels when gaps form in the canopy. Seed spread varies across regions. According to Landenberger and colleagues in 2007, movement patterns differ based on environmental factors. Through transect-based seed collection, researchers examine how surroundings shape plant distribution patterns using regression alongside three-factor ANOVA to assess influences. Cabra-Rivas and team reported findings in 2014 a team ran a test outdoors, placing seeds into stretches of a stream while tracking what happened afterward. Some segments received seed deposits; others did not - patterns emerged over time through close watching floating seeds move differently depending on how water flows, while the amount that stay trapped changes with current patterns.

Though several studies explored pathogens alongside possible biocontrol methods, each approached the topic differently. From infected trees, Rebek and team in 2013 gathered samples, growing fungi on specialized media before identifying them through physical traits and DNA analysis, then testing disease potential under glasshouse conditions. Rather than lab work alone, Snyder and colleagues across 2012 and 2014 expanded into open fields, observing how aggressively Verticillium nonalfalfae spreads using controlled plant infections. Instead of original data, Ding et al., back in 2006, pulled together prior research, weighing insect and fungal agents based on how precisely they target hosts and whether that makes them strong candidates for biological suppression strategies. Recently, work by Bubici and colleagues in 2020 examined Ailanthus altissima linked to Aleurocanthus spiniferus through field observations, blending physical traits analysis with sRNA-Seq alongside computational methods. In parallel, research led by Kashefi in 2022 explored Aculus mosoniensis presence across natural sites, relying on visual classification together with COI gene data to assess genetic differences and spatial trends.

One reason method differed among studies was the kind of question each team aimed to answer. When looking at weedkillers and ways to manage plants, scientists often applied treatments outdoors then watched changes over time. Instead of outdoor work, those exploring plant reactions under pressure ran tests in stable conditions to track how systems responded. To understand movement patterns, researchers paired real-world observations with number-based tools that revealed trends. For organisms meant to limit growth, investigators turned to lab cultures, gene-level checks, and sheltered growing spaces - each helping show how attackers linked with hosts and whether they might help control spread.

Work continues on Ailanthus altissima in Azerbaijan's Absheron area, studying how it spreads and alters ecosystems locally. Because environmental changes matter, scientists look closely at shifts in plant communities, ground composition, and biological variety. Some investigations turn toward practical roles - such as wood supply or energy feedstock - as one path forward emerges. Although eradication proves difficult, teams test physical clearing methods alongside targeted herbicide use and watch how seeds move across spaces. These combined actions support sharper insights into regional patterns of growth while shaping realistic ways to manage unwanted expansion. When results accumulate, clearer options appear for handling the species without worsening disruption elsewhere.

4.Conclusions

From what has been studied so far, a few main points stand out clearly:

1. Looking at current studies shows *Ailanthus altissima (Mill.)* - originally from northern and central China - has turned into a highly disruptive invader across global ecosystems. Though first introduced outside its range for ornamental purposes, it now outcompetes local flora in diverse climates. Its rapid growth allows dense stands to form quickly, especially in disturbed areas like roadsides or abandoned lots. Because it releases chemicals that hinder nearby plant development, few species can survive near mature individuals. While some regions attempt mechanical removal, resprouting after cutting makes long-term control difficult. In contrast to slower-growing natives, this species adapts fast to urban pollution and poor soils. Over time, persistent colonization alters soil composition and reduces biodiversity in invaded zones.

2. Despite dry conditions, *Ailanthus altissima* manages its water well through specific adaptations. Stomatal regulation plays a role, while reduced root hydraulic conductivity helps limit excessive loss. Together, these traits support survival when moisture is scarce. The tree maintains function even as soil water declines sharply. Evidence shows it prioritizes conservation over rapid uptake. Rather than deep foraging, it adjusts internally to stretch available supplies. Under stress, growth slows but physiological balance holds. This resilience emerges from coordination between leaf and root behaviors. Water savings accumulate not by one method alone, yet through linked strategies. Prolonged droughts become tolerable due to such integrated responses.

3. When it comes to handling *Ailanthus altissima*, studies show relying only on physical removal tends to fail - sometimes backfiring when cut stems respond with vigorous sprouting, increasing overall numbers. Though straightforward, chopping down these trees often leads to denser stands rather than reduction, making the issue harder to manage over time.

4. In Azerbaijan, work is underway to develop management strategies, including mechanical removal, chemical control and seed dispersal monitoring, to prevent further spread in urban and natural areas.

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