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European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes PM 9/29 (1)

National Regulatory Control Systems

PM 9/29 (1) *Ailanthus altissima*

Specific scope

This Standard describes the control procedures aiming to monitor, contain and eradicate *Ailanthus altissima*.

Specific approval and amendment

First approved in 2019–09.

1. Introduction

Further information on the biology, distribution and economic importance of *Ailanthus altissima* can be found in EPPO (2018) and CABI (2018).

Ailanthus altissima (Mill.) Swingle (Simaroubaceae) is a broadleaved perennial early successional tree that is native to Asia (China and Vietnam). The species can grow up to 30 m in height and has alternately arranged compound leaves (Kowarik & Säumel, 2007). The species is mainly dioecious (male and female flowers occurring on different trees). In the EPPO region flowering generally occurs during July and August (Holec *et al*., 2014). Natural spread is via the production of winged fruits, which are wind dispersed up to 120 m from the parent plant (Kowarik & Säumel, 2007). The fruits can also become incorporated into water bodies and spread over long distances (Kowarik & Säumel, 2006, 2007, 2008; Säumel & Kowarik, 2010). Recent research has shown that *A. altissima* seeds can remain viable for more than 5 years when buried at depths of 10 cm (Rebbeck & Jolliff, 2018). Clonal expansion through root sprouting can occur spontaneously or be initiated by disturbance and is effective for local-scale spread and colonization (Kowarik & Säumel, 2007). The species can regenerate from root fragments (Kowarik & Säumel, 2007).

Ailanthus altissima has been introduced as an ornamental species to many countries/regions of the world, including Africa (South Africa), East Asia (India, Pakistan and Japan), Central Asia (Iran, Israel and Turkey), Oceania (Australia and New Zealand), North America (Canada, Mexico and the USA) and South America (Argentina and Chile). In the USA, the species is widespread throughout almost all States. *Ailanthus altissima* was introduced into the EPPO region as early as the 1740s (Hu, 1979). The species has been widely planted for ornamental and many other uses (e.g. forestry and erosion control; Kowarik & Säumel, 2007) throughout the region and has become invasive in many countries with the exception of the Nordic countries and Russia (EPPO, 2018). *Ailanthus altissima* can have negative impacts on native biodiversity through direct competition and through allelopathic effects (Kowarik & Säumel, 2007). The species can have negative impacts on ecosystem services as well as negative economic impacts by affecting infrastructure (Kowarik & Säumel, 2007; Constán-Nava *et al*., 2014). The species can have human health implications as contact with the leaves can cause severe dermatitis and the pollen can cause allergic reactions (Bennett *et al*., 2013).

Ailanthus altissima has been included on the EPPO List of Invasive Alien Plants since 2004 (EPPO, 2018). The species is regulated in a number of EPPO countries. In Poland, Portugal and Spain, it is a Regulated Invasive Alien Plant whereas in Russia and Ukraine, it is a Regulated Non-Quarantine Pest. In Belgium, Germany and Switzerland (Black List), the species has been included in the list of Invasive Alien Plants (EPPO, 2018).

Ailanthus altissima is more restricted to urban habitats in temperate climates but it is also frequent also in rural areas in meridional and Mediterranean climates. *Ailanthus altissima* is commonly found in urban areas, particularly on disturbed sites such as waste land and transportation networks, e.g. railway embankments and roadsides (Kowarik & Säumel, 2007; Constán-Nava, 2012; Follak *et al*., 2018). The species also is known to invade archaeological sites within the EPPO region (Celesti-Grapow & Blasi, 2004; Vidotto *et al*., 2015). The species has been reported to spread in arable land, including abandoned land throughout the EPPO region, usually along hedgerows (Fotiadis *et al*., 2011). In addition, the species has been recorded in perennial cropping systems (e.g. vineyards, olives groves and almonds groves; Nestorovic & Jovanovic, 2003). In the southern and southwest France, *A. altissima* is increasingly found in vineyards. It seems very difficult to control, particularly along the grapevine rows where mechanical control possibilities are limited (to avoid damaging the grapevine). Additionally, in the case of organic vineyards, herbicides are not allowed. It can also invade (semi-)natural habitats including pine, oak and riparian forests (Kowarik, 1983; Lepart & Debussche, 1991; Kowarik & Säumel, 2007; Constán-Nava, 2012), scrubland, and costal dunes (Ampe & Langohr, 2003; Ciccarelli *et al*., 2012). Its presence in (semi-)natural habitats is mostly related to natural or human disturbance (e.g. transportation networks and forest clearings).

Ailanthus altissima can grow in poor soils and is resistant to disturbed or stressed habitats. The species is also tolerant to salt, which is one reason the species can persist along roadsides where salt is used in wintertime. The species tolerates a broad amplitude of climatic conditions, humidity, light and moisture levels. It is highly tolerant of poor air quality (pollution) in urban areas but is sensitive to ozone. *Ailanthus altissima* is adapted to drought stress due to its extensive root system and the water-saving strategies of the foliage (Constán-Nava *et al*., 2010). The species is mostly classified as intolerant of shade (e.g. Kowarik, 1995; Kowarik & Säumel, 2007). However, a recent study shows a higher shade tolerance, in particular of juvenile plants (Knüsel *et al*., 2017). The species is sensitive to frost in the early life stage (Kowarik & Säumel, 2007).

Pathways for entry into, and spread within, the EPPO region include horticulture, forestry and seed contaminants of trade and soil movement (Pergl, 2017). The discarding of *A. altissima* garden waste can also facilitate the spread of the species within the region (Brundu, 2017).

EPPO member countries at risk are advised to prepare monitoring activities and a contingency plan for the eradication and containment of this pest.

This Standard presents the basis of a national regulatory control system for the monitoring, eradication and containment of *A. altissima* and describes:

- elements of the monitoring programme that should be conducted to detect a new infestation or to delimit an infested area.
- measures aiming to eradicate recently detected populations (including an incursion).
- containment measures to prevent further spread in a country or to neighbouring countries in areas where the pest is present and eradication is no longer considered feasible.

Regional cooperation is important, and it is recommended that countries should communicate with their neighbours to exchange views on the best programme to implement in order to achieve the regional goal of preventing further spread of the pest.

For the efficient implementation of monitoring and control at a national level, cooperation between the relevant public bodies (e.g. NPPOs, ministries of environment and forests, urban planning departments, ministries in charge of transport, water management, etc.), as well as with other interested bodies (associations) should be established.

2. Monitoring of *Ailanthus altissima*

Staff of organizations in charge of the monitoring of the species should be trained to recognize the plant at all stages in its lifecycle (including distinguishing male and female plants), even when present as small populations. This may include staff of NPPOs, nature conservation managers as well as botanists, agronomists, farmers and forest managers etc. As this plant has the potential to grow in a range of habitats, citizen science projects may be implemented to encourage landholders and other citizens to report sightings of *A. altissima*.

Regular surveys (according to the ISPM 6 *Surveillance*, FAO, 2018) are necessary to determine the geographical distribution of the plant and its prevalence. Monitoring should concentrate on areas that are climatically suitable and most vulnerable to colonization (riparian systems, open habitat complexes, mesic roadsides, transport corridors and forests; see above for a more comprehensive list of habitats).

Usage of photographs (both aerial and from the ground) and the use of drone technology can assist in surveillance (Rebbeck *et al*., 2015).

3. Eradication of *Ailanthus altissima*

Any eradication programme for *A. altissima* in the case of recently detected populations (including an incursion) is based on the delimitation of the infested area within the country and the application of measures to both eradicate and prevent further spread of the pest. The feasibility of eradication depends on the size of the area infested, the habitat type, accessibility of the habitat and environmental/legal restrictions invaded (it may be more difficult to eradicate *A. altissima* along riverbanks and in closed wooded habitats), the connectivity of individual stems within the population, the density of the population and accessibility of the site, the probability of re-invasion, and the resources available. Importantly, repeated management measures are required to eradicate populations, with all individuals treated simultaneously. For any eradication programme to be successful in the long term, habitat restoration is an essential component of the programme.

Measures are described in Appendix 1.

4. Containment of *Ailanthus altissima*

The containment programme for *A. altissima* in the case of established populations is based on the application of measures to prevent further spread of the pest in the country or between neighbouring countries. These measures are described in Appendix 2.

5. Communication and collaboration

Professionals (administrations, in particular road administrations, the nursery industry, municipal nurseries, private road companies, etc.) should be informed by NPPOs, ministries of environment and forests, urban planning departments and ministries in charge of transport and water management about the threat of *A. altissima* to natural and managed land and infrastructure, and about preventive measures. The first step in controlling *A. altissima* would be to stop its use as an ornamental plant, in particular along roads and near habitats at risk. In this regard, the public and local administrations should be informed by researchers and local administrations about the threats the species can pose to the natural environment and human health. Integrated management, involving different sorts of land managers and various management measures, will be more effective and efficient. Regional cooperation is essential to promote phytosanitary measures and information exchange in identification and management methods. NPPOs can provide land managers and stakeholders with identification guides and facilitate regional cooperation, including information on site-specific studies of the plant, control techniques and management. Additionally, local/regional authorities can provide members of the public with information concerning any restrictions for the utilization of the species within an area or region.

Citizen science projects may be implemented to encourage landholders and other citizens to report sightings of *A. altissima*. As an example, in Croatia citizen scientists have utilized a freely available app to detect over 2600 m^2 of *A. altissima* dispersed throughout the country (Sladonja & Poljuha, 2018).

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Appendix 1 – Eradication programme

The national regulatory control system involves four main activities:

1. Surveillance to fully investigate the distribution of the pest.
2. Containment measures to prevent the spread of the pest.
3. Treatment and/or control measures to eradicate the pest when it is found.
4. Verification of pest eradication.

Eradication depends on effective surveillance to determine the distribution of the pest and containment to prevent spread while eradication is in progress. Any eradication measures must be verified by surveillance to establish if attempts and measures have been successful.

Staff in charge of the control of the plants should be warned about the health risk associated with the species and should avoid touching the plant with bare skin (Bennett *et al*., 2013). All body parts should be covered with protective clothing, synthetic water-resistant material being preferred since cotton and linen fibres soak up the plant sap. Gloves with long sleeves should be worn, and when cutting the plants, protective glasses should be used to prevent drops of plant sap entering the eyes. After control, protective clothes should be taken off and cleaned in order to avoid any contact of the sap of *A. altissima* that may be on the clothes with the skin.

The possible methods for treatment and control depend on the environment in which they may be applied. The presence of protected or endemic species should be considered as well as the breeding seasons of fauna and the fragility of the ecosystem, in particular forests, and any existing regulations should be checked.

1. Surveillance

A delimitation survey should be conducted to determine the extent of the pest distribution. Infested areas and adjacent areas that might receive seed should be monitored. Particular attention should be given to high-priority habitats (i.e. interconnecting habitats that have previously been recorded to harbour *A. altissima*) such as connecting waterbodies and transportation networks (roads and railways) close to any infested areas. In addition, surveillance should be conducted in arable land, including abandoned land and perennial cropping systems (e.g. vineyards, olive groves and almond groves) and in (semi-)natural habitats including pine, oak and riparian forests, scrubland and costal dunes. Brundu (2017) states that any effective surveillance system for achieving early detection of a new occurrence should take into account the pathways of introduction and spread, the location and distribution of existing infested areas, and the susceptibility of habitats.

2. Containment measures

Unintentional transport of seed and propagules through the transfer of soil material, human activity, the movement of grazing animals and by vehicles should be avoided (von der Lippe *et al*., 2013; USDA, 2014). Movement of soil which may contain seeds and root material from infested areas should be prohibited. Equipment and machinery should be cleaned to remove soil before moving to an uninfected area (see ISPM 41 *International movement of used vehicles, machinery and equipment*; FAO, 2017). Awareness campaigns that target relevant groups (e.g. hikers) by providing information on how to identify the species, and how to decontaminate boots and clothes from seed are recommended (e.g. Council of Europe, 2017).

3. Treatment and control

To date, managing *A. altissima* invasions has mostly involved chemical control or mechanical removal (Brundu, 2017). It should be noted that *A. altissima* is a difficult species to control and an integrated management approach, i.e. using chemical and manual control options together (Kowarik & Säumel, 2007; Biosecurity Queensland, 2013) and in combination with habitat management (Brundu, 2017), is advised as re-sprouting is common. Radtke *et al*. (2013) demonstrated that if a tree is cut and the stump is left in the ground, new sprouts from lateral roots of the mother plant may occur up to 50 m from the parent tree. It is therefore crucial to target all individual plants connected to the root system because if any are left untreated they may promote re-sprouting.

High seed production and dispersal by wind can make the management of this species difficult. Considering that the species is mainly dioecious (i.e. male and female flowers occur on different trees), monitoring programmes and first actions of control should be always initially targeted towards individual female trees. In addition, the regeneration capacity of the species can lead to complications in the management of the species. Management is very difficult once the species has established a taproot (Kowarik & Säumel, 2007) thus in general young individuals can be most efficiently controlled.

Treatment of infested areas can be applied on a tree size basis if the majority of plants are at a similar size of development. All methods should be repeated (both within and between years) and applied consistently to all individuals until the plant/population is eradicated. The treated areas should be monitored for at least 5 years irrespective of the management method.

Table 1 details the effectiveness of some of the management methods.

Manual and mechanical control

Hand-pulling can be effective on very young seedlings, but this method becomes ineffective once the root system has developed and extended (Kowarik & Säumel, 2007; USDA, 2014). Effective hand-pulling can be carried out at any time of the year, but it is recommended that seedlings are pulled when the soil is moist to aid removal and ensure that the entire root system is removed. Hand-pulling should be conducted with care when the infestation of man-made structures may pose structural concerns (e.g. wall and foundation stability) as removal attempts may worsen the problem (particularly in historical sites).

Girdling can be carried out at any time of the year. The aim of this method is to interrupt the flow of sugars from the crown to the roots, which causes slow death of the tree. It involves using an axe or hatchet to make a horizontal cut or groove at the base of the tree through the bark and cambial tissue around the entire circumference of the trunk, leaving the wood intact. The width and depth of the groove should be in proportion to the tree’s diameter. Three small grooves for older trees or one groove with a wider height (e.g. 10 cm) for young trees are recommended. Any re-sprouting can be removed physically. The tree should not be cut at the base before death (Wunder *et al*., 2016).

Plants treated through girdling could stand for a long time until death and single branches or the entire tree may fall unexpectedly. For this reason, this technique should not

Table 1. Effectiveness and applicability of control methods according to the literature for individual size classes of *Ailanthus altissima*

Methods	Effectiveness and applicability[†] Seedlings (without taproot)	Young trees (up to 2 m tall)	Adult trees	Comments
Hand pulling	+++	NA	NA	Suitable for all habitats, special care for historic sites. Difficult when soil is dry.
Girdling	NA	++	+++	Can be problematic in urban areas, along transportation networks and in windy areas due to falling trees. Suitable for habitats where herbicides are not permitted.
Mechanical removal	+	–	–	Habitat accessibility limits method. Not to be used as a standalone method.
Foliar spraying	+++	+++	NA	Depends on country approvals of herbicide applications. Chemicals used with caution.
Basal bark spraying	NA	+	+	Depends on country approvals of herbicide applications. Labour-intensive method.
Stump treatment	NA	+++	+++	Depends on country approvals of herbicide applications.
Stem injection	NA	++	+++	Can be problematic in urban areas, along transportation networks and in windy areas due to falling trees. Depends on country specifications.
Frilling	NA	+++	++	Can be problematic in urban areas, along transportation networks and in windy areas due to falling trees. Depends on country specifications.
Burning	–	–	–	Not recommended as it promotes re-sprouting.

*Potential effectiveness is indicated with + and –, where +++ indicates most effective and – indicates counterproductive; NA, applicable. Effectiveness may be scale, site and habitat dependent (+++ does not give a guarantee of 100% control). Repeated applications of any methods will be required and often a combination of methods is needed, although for simplicity this table does not address combined methods.

be applied in residential areas or other areas frequently visited by the public, nor in proximity to roads, highways and railways.

In Switzerland and Austria, control based on accurate girdling and physical removal of re-sprouts has proved to be effective (Wunder *et al*., 2016; Praxishilfe invasive Neophyten, 2018).

Mechanical removal using heavy machinery can be effective for removing aboveground material but this method is non-selective and other vegetation may be removed in the process. Following the removal of the tree to the stump, the stump can be removed (including the roots) or can be ground. The former process is more laborious than the latter and it is not always feasible to remove the whole root ball from the ground.

Mechanical removal of the aboveground foliage, stems and trunks can be conducted using a variety of operational tools, including brush cutters, chainsaws, axes, loppers and clippers. Methods involving the multiple cutting of stumps can be ineffective, even when stumps were cut twice during one year and again in the following years (Constán-Nava *et al*., 2010).

Chemical control

It should be highlighted that the availability of products containing active substances will vary nationally and other products may be available and effective. Indications of the approved uses for each active substance may be incomplete. Products should be used following the instructions on the label and in line with the relevant plant protection product regulations. Before using a product, it must be verified that the type of application which will be adopted (foliar, basal bark, stump treatment, stem injection) follows the manufacturer's instructions on the label. In addition, the use of herbicides in, for example, fallow fields or in the vicinity of water could be restricted by national legislation, which should be consulted before any herbicidal application. Policies often aim to reduce the amount of pesticides and protect groundwater from herbicides.

There are two main chemical control options: herbicide application targeting the foliage and spot chemical application targeting the stem or stump. Applying a colour dye to the chemical mixture can help identify treated trees.

Systemic herbicides should be applied before the end of the growing season, when resources are moved to the root system. Exact timing can vary depending on the climatic region.

Foliar spraying may be used to control young trees and regrowth from the stump and root system. The most commonly used herbicides are glyphosate and triclopyr, and they are absorbed through the leaves and transported to the root system (USDA, 2014). It is recommended that chemical application to the foliage is applied in the active growth season of the plant. To limit the risk of unintentionally spraying of other trees and shrubs or herbaceous vegetation growing in the proximity of plants to be treated, foliar spraying should be avoided for plants taller than 2 m.

Basal bark spraying can be used when the tree is fully leaved but as it is labour intensive, it is best applied to small infestations or isolated trees (USDA, 2014). For basal bark spraying, systemic herbicides should be applied. Triclopyr is the most commonly used herbicide for this method mixed at 20% (20% triclopyr:80% crop oil solution) (USDA, 2014). USDA (2014) details 'For trunks <6 inches [15.2 cm] in diameter, a continuous 12-inch [20.4 cm] wide band should be sprayed around the tree base. For trunks >6 inches [15.2 cm], apply a 24-inch [60.9 cm] band'.

As part of an EU-funded project (EMPHASIS1) to evaluate the control of *A. altissima* in amenity and non-agricultural areas, the University of Turin (IT), Department of Agriculture, Forestry and Food Science tested the effectiveness of basal bark application. In the respective trials, the active substances glyphosate, fluroxypyr + aminopyralid and fluroxypyr + triclopyr were compared and applied to the first 50 cm of stem from the ground. The effect of the treatments was limited (approximately 30–40% mortality) and no differences were found between the tested herbicide combinations (Fogliatto *et al*., 2016; Gaile *et al*., 2018; Milan *et al*., 2018).

Stump treatment (application to cut stems and stumps) can be applied by using systemic herbicides directly following the cutting of the tree and re-sprouting (Constán-Nava *et al*., 2010). Dufour-Dror (2013) notes that the treatment should be applied quickly to the trunk following cutting and applied to the cambial regions of the newly cut stem so the chemical compound can penetrate into the sapwood. The herbicide can be applied with a paintbrush directly onto the stump of the tree. Trials performed in Cyprus (using both triclopyr and glyphosate) did not show any significant differences between the effects of these two herbicides. Research from the USA has shown that cut stump treatment with imazapyr and triclopyr (20% v/v in oil) resulted in more than 90% reduction in both vigour ratings and re-sprouting of single stems and clumps (DiTomaso & Kyser, 2007).

Results from the EMPHASIS project showed that for the cut-stump herbicide treatment, the use of fluroxypyr + aminopyralid gave the best results (compared to cutting alone, glyphosate or fluroxypyr + triclopyr) in terms of the reduction in the number and length of the re-sprouts (F. Vidotto, pers. comm. 2018).

Best results are usually obtained when treatments are performed in late summer (August/September).

Stem injection can be applied to trees where holes are drilled in the tree and a systemic herbicide is injected into each hole using a syringe. A single hole can be sufficient for small plants (diameter at breast height (DBH) approximately 5 cm), but for bigger plants more holes may need to be drilled (Milan *et al*., 2018). The recommended ratio between the diameter of the stem and the sum of the area of drilled holes is 25–30% at a depth of 2–3 cm. In a field study carried out in northwest Sicily, Badalamenti & La Mantia (2013) drilled a single hole and used an undiluted formulation of glyphosate (containing 360 g L^{-1} of active substance) and injected 1 mL into trees with a DBH of <8 cm and 2 mL when the DBH was larger than 8 cm. Both methods were shown to kill 90% of treated trees. Triclopyr can also be applied in this way (Dufour-Dror, 2013). Studies in the USA have shown that for stem injection treatments, undiluted imazapyr can give good results (>95% canopy reduction), and glyphosate also provided excellent control (92% canopy reduction) (DiTomaso & Kyser, 2007).

Plants treated through stem injection are progressively affected by herbicide action and death may occur some time after treatment. Plants could stand for long time until death and single branches or the entire tree may fall unexpectedly. For this reason, this technique should not be applied in residential areas or other areas frequently visited by the public, nor in proximity to roads, highways and railways.

Frilling (cutting of the bark) followed by systemic herbicide application is an effective method to control *A. altissima* and it has been shown to kill up to 95% of treated individuals (Dufour-Dror, 2013; Penn State, n.d.). The method is suited to young trees and saplings where bark is easily destroyed and drilling is not feasible. A knife is used to debark a section of the stem and the herbicide (triclopyr or glyphosate) is applied using a small paintbrush.

Cultural control

In areas where ground cover of plants can be managed to maintain dense vegetation (and in neighbouring sites) this can help to prevent the establishment of *A. altissima* (Penn State, n.d.).

Best practices should be applied for plantations of *A. altissima* used in short rotation forests to avoid impacts on the wider environment (McKay, 2011; Brundu & Richardson, 2016).

Integrated control

Depending on the infested site a combination of mechanical, chemical and other methods (e.g. biological control) may be required to eradicate *A. altissima* (see above and Appendix 2).

Constán-Nava *et al*. (2010) tested three treatments applied annually for 5 years in Mediterranean forests (one-cut stump treatment, double-cut stump treatment and cut stump and glyphosate application) and concluded that only cut stump and glyphosate application was able to reduce the long-term growth and spread of the species. However, other methods in other regions have proved effective.

Disposal

Plant waste generated in the elimination works should be piled up, and contact with water and with the ground should be avoided. If the waste has flowers and seed material, they should be piled at the bottom to prevent seed dispersal by wind. It is not recommended that plant material which has been collected, and contains herbicide residues, is left in the environment. If necessary, waste can be removed in large sacks. After stocking up the waste, authorized burning can be performed, ensuring that no seeds are

[1]http://www.emphasisproject.eu/.

present as they could be spread by the hot air. The waste could also be burned in an incinerator, but this is very expensive. Alternatively, it could be removed to an authorized landfill in closed containers in order not to spread seeds. The waste should be immediately covered once it reaches the landfill. The safety of waste should be carefully evaluated.

4. Verification of pest eradication

Mechanical measures and chemical application should be conducted until no signs of *A. altissima* are found. Dyes in the herbicide mixtures help to verify accuracy of treatment. As seed can remain viable for over 5 years, repeated visits should be made to managed sites for at least 5 years after all above- and belowground material has been exhausted.

Appendix 2 – Containment programme

In the case of an established population, eradication may be difficult to achieve. Containment measures aiming to prevent further spread of the pest to endangered areas or to neighbouring countries should be applied. While different approaches have been used to manage *A. altissima*, an integrated approach is recommended. Habitat restoration post-removal may facilitate recolonization due to disturbance. Planting of native tree or shrub species can act to prevent re-establishment.

Surveillance

See Section 1, Appendix 1.

Containment measures

Containment measures regarding the prevention of the spread naturally or through the movement of soil, machinery, livestock or any contaminated commodity should be applied (Section 2, Appendix 1).

For mechanical, chemical and cultural control measures, along with disposal of plant biomass refer to Section 3, Appendix 1.

Biological management

The use of any biological control agent within the EPPO region should be evaluated using PM 6/04 *Decision-support scheme for import and release of biological control agents of plant pests*.

Biological control has been evaluated for *A. altissima* in both the EPPO region and the USA. Ding *et al*. (2006) report that 46 phytophagous arthropods, 16 fungi and one potyvirus were reported attacking *A. altissima* in its native range. Two weevils, *Eucryptorrhynchus brandti* and *E. chinensis*, both from China, are reportedly specific to *A. altissima* and have shown show promise as potential classical biological control agents (Ding *et al*., 2006). At present, there are no classical biological control agents available for the species within the EPPO region.

Verticillium nonalfalfae has been proposed as a biological control agent. The soil-borne fungus was first observed killing *A. altissima* individuals in forests in south-central Pennsylvania (USA) (O'Neal & Davis, 2015). *Verticillium nonalfalfae* has been shown to kill both the above- and belowground parts of the tree. *Verticillium nonalfalfae* and *V. dahliae* have also been reported from wilting *A. altissima* trees in the EPPO region (Maschek & Halmschlager, 2017). An Austrian isolate of *V. nonalfalfae* was identified in the natural environment and stem inoculation experiments have shown it can cause 85% mortality to *A. altissima* (Maschek & Halmschlager, 2017). A bioherbicide has been approved for use in Austria (for 120-day period in 2017 and 2018) under Emergency Authorisation according to article 53 of Regulation (EC) No 1107/2009 (BAES, 2019).

A commercial stump treatment based on the fungus *Cylindrobasidium laeve* has been utilized in South Africa and has been shown to be effective in the management of the species, with results showing it can kill 80% of treated stumps (Lennox *et al*., 1999).