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European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes PM 9/24 (1)

National regulatory control systems
Systèmes de lutte nationaux réglementaires

PM 9/24 (1) *Microstegium vimineum*

Specific scope

This Standard describes the control procedures aiming to monitor, contain and eradicate *Microstegium vimineum.*

Specific approval and amendment

First approved in 2017-09.

1. Introduction

Details on the biology, distribution and economic importance of *Microstegium vimineum* can be found in EPPO (2016).

Microstegium vimineum (Trin.) A. Camus (Poaceae) is an annual C4 grass with a sprawling habit. It germinates in spring and grows slowly until mid-summer, ultimately reaching a height of 0.6–1.5 m. Reclining stems can grow to a length of as much as 2 m. In unfavourable conditions, the plant can be as small as 10–20 cm high, but it is still capable of producing flowers and seed. *Microstegium vimineum* is native to Bhutan, China, India, Iran, Japan, Myanmar, Nepal, the Philippines, Taiwan, Thailand and Vietnam. Within the EPPO region, *M. vimineum* is established in the Southern Caucasus including Azerbaijan, the Republic of Georgia and Turkey (EPPO 2016), native to the Russian Far East (Tsvelev, 1976) and introduced to Northern Caucasus (Valdés *et al.*, 2009). *Microstegium vimineum* was first identified in the United States in 1919 in Tennessee and by 1960 had spread to Ohio and Pennsylvania and to all Atlantic coastal states from Florida to New Jersey. It is currently found from Massachusetts to Florida and west to Texas and Missouri. *Microstegium vimineum* may have been introduced when its dried leaves were used as a packing material for porcelain shipped from China to the United States (Mehrhoff, 2000; USDA, NRCS, 2008; Fryer, 2011).

Microstegium vimineum thrives along mesic roadsides, ditches, woodlands, lowland woodlands, woodland borders, floodplains and streamsides, field margins and turfgrass (Fairbrothers & Gray, 1972; Hunt & Zaremba, 1992). It can also be found in mesic upland sites, and performs best in high-light, high-moisture conditions (Droste *et al.*, 2010; Flory *et al.*, 2011a). An individual plant can produce thousands of seeds, which remain viable in the soil for 3–5 years (Barden, 1987, 1991; Gibson *et al.*, 2002; Judge, 2005; Huebner, 2011). Seed is likely to survive most modes of transport and extended periods of storage. Seed does not lose viability even at −21°C (Judge, 2005).

The most likely pathway for the entry for *M. vimineum* is via seed as a contaminant. *Microstegium vimineum* could have been introduced into Britain in birdseed (Hanson & Mason, 1985) and viable plants have been grown from birdseed stock (Ryves *et al.*, 1996). Seed may be present in growing media adherent to plants for planting. *Microstegium vimineum* seed may attach to human clothes and shoes, and in the USA it has been observed to be spread by hikers (Mehrhoff, 2000 in CFIA, 2009).

Microstegium vimineum forms dense stands that change plant community richness (number of species), plant diversity and overall groundcover by out-competing other species (Adams & Engelhardt, 2009; Flory & Clay, 2010a,b; Meiners, 2010). It may affect native species through multiple mechanisms including competitive exclusion, changing soil properties, reducing light availability and increasing native consumer activity. *Microstegium vimineum* alters soil conditions, forming a positive feedback by increasing pH, nitrification and nitrate, which may act to inhibit native species (Fraterrigo *et al.*, 2011; Lee *et al.*, 2012).

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 *Microstegium vimineum* 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, environment and transport ministries, water management, etc), as well as with other interested bodies (associations) should be established.

An EPPO pest risk analysis for *Microstegium vimineum* (EPPO, 2015) can be found in https://gd.eppo.int/taxon/MCGVI/documents

2. Monitoring of *Microstegium vimineum*

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

Regular surveys (according to the International Standard for Phytosanitary Measures (ISPM) 6 *Guidelines for surveillance*) 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 (mesic roadsides, transport corridors and forests; see EPPO (2016) for a more comprehensive list of habitats).

3. Eradication of *Microstegium vimineum*

Any eradication programme for *M. vimineum* 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 density of the population and the accumulated seed bank, and accessibility of the site.

Measures are described in Appendix 1.

4. Containment of *Microstegium vimineum*

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

5. Communication and collaboration

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.

Professionals (e.g. administrators, foresters) should be informed about the threat to natural and managed land and about preventive measures. Integrated management, involving different sorts of land managers and various management measures, will be more effective and efficient.

6. Acknowledgements

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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.

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.

Containment measures

Unintentional transport of seed through the transfer of soil material, human activity, the movement of grazing animals and by vehicles should be avoided. Movement of soil from infested areas should be prohibited. Equipment and machinery should be cleaned to remove soil before moving to an uninfected area. The International Plant Protection Organization is currently drafting a Standard on 'International movement of used vehicles, machinery and equipment', providing guidance on how to treat, how to set up facilities and waste disposal, and how to check procedures (IPPC, 2014). On arrival, grazing animals should be held in yards or small paddocks until seeds have dropped from their coats and tails prior to their release. Infestations around yards can be easily spotted and controlled. Awareness campaigns that target hikers, for example by providing information on how to identify the species, and how to decontaminate boots and clothes from seed are recommended.

Treatment and control

Chemical control

Non-selective foliar herbicide glyphosate-based products can be applied to the foliage of *M. vimineum* at any time during the active growing season. However, chemical control using non-selective herbicides is not recommended since there are selective herbicides that are effective and

cause much less harm to native species and allow for tree regeneration (Kleczewski *et al.*, 2011).

Microstegium vimineum often occurs at high density along disturbed corridors, such as waterways and trails and within otherwise undisturbed forests. In a study in the USA, Flory (2010) evaluated the use of hand weeding and two herbicide treatments [grass-specific post-emergent herbicide (POST) and post-emergent herbicide plus a pre-emergent herbicide (POST + PRE)] for eradicating invasions of *M. vimineum*. Controls were used for standardization. Hand weeding involved pulling and removing all plants of the species from a defined area. The POST treatment consisted of 0.21-kg active substance (as) per hectare of fluazifop-*p*-butyl (0.84 kg ha^{-1} Fusilade DX; Syngenta Crop Protection) mixed with 14.8 mL of non-ionic adjuvant surfactant (Surf Plus 584; Townsend Chemical Division). For the POST + PRE treatment, the PRE treatment was applied in the spring following the application of POST. The PRE treatment was 1.34 kg as ha^{-1} of pendimethalin (1.35 kg ha^{-1} Pendulum AquaCap; BASF). Both herbicides were applied using a backpack sprayer. Hand weeding and POST were conducted in July 2005 and June 2006, and PRE treatment was applied before *M. vimineum* germination in April 2006 and 2007.

POST was effective at eradicating *M. vimineum*, particularly after 2 years of treatment, and resulted in only a small spring re-emergence of the plant. POST resulted in increased productivity of the resident plant community and spring cover the following season. Although POST + PRE were also an effective treatment for removing *M. vimineum* biomass, the treatment did not allow for recovery of the resident plant community.

It should be highlighted that the availability of products containing these 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.

Manual and mechanical control

Hand-pulling can be used to remove *M. vimineum* during the growing season, but studies have shown that after 2 years of treatment significant reinvasion occurs (Flory, 2010). Hand pulling was shown to have a positive effect on native plant communities, with a 24% greater native plant diversity compared with controls (Flory & Clay, 2009). The labour and time required to conduct the hand-pulling treatment prohibit its use except for small, isolated invasions. Hand pulling can be an effective method of controlling isolated, small populations of *M. vimineum*. However, the timing for this method is important. Hand pulling late in the season but before the plant has set seed reduces the likelihood of spreading the current season's seeds. Care should be taken not to hand-pull early in the season as this can act to allow new germination from the seed bank (Tu, 2000). Hand-pulling of plants will need to be repeated for a number of seasons until the seed bank is exhausted (Swearingen, 2000). Repeated hand-pulling within one season can reduce the amount of grow-back the following season (Flory, 2010).

Mowing has been successfully utilized to manage *M. vimineum* but its application is limited to roadsides, open areas and footpaths that will accommodate mowing equipment. The timing of mowing during the season is considered important for effective control (Shelton, 2012). Mowing is effective if carried out late in the summer months just before seed production (Swearingen, 2000; Tu, 2000). Mowing at other times in the season may allow for resprouting and should be avoided (Woods, 1989).

Shelton (2012) tested the effectiveness of mowing at three different times of the year between mid-June and early September in the USA, as well as mowing twice in one year over a 2-year period. Early mowing (just after the

Table 1. Possible control methods for *Microstegium vimineum* invasions. Table modified from Kleczewski *et al.* (2011).

Possible methods to manage invasive *Microstegium*			
Treatment	Tested	Recommended	Notes
Pre-emergent herbicide	Yes	No	Prevents establishment of *Microstegium* and native plants (e.g. pendimethalin)
Non-selective herbicide	Yes	No	Kills *Microstegium* and native plants (e.g. glyphosate)
Grass-specific herbicide	Yes	Yes	Extremely effective. Can prevent recolonization of sites the following year with minimal damage to non-sensitive species. Grass-specific herbicides are products that contain the active ingredients clethodim, fluazifop-*p*-butyl, sethoxydim or others. However, be aware that grass-specific active ingredients are sometimes packaged with other herbicides
Hand-weeding	Yes	Yes	Practical for small, isolated invasions. Must be repeated multiple times per year, potentially for multiple years
Mowing	Yes	Yes	Particularly important that this is timed before seed set to avoid spread with machinery. Practical for flat areas with few trees
Controlled burning	Yes	No	Not yet known how to best time fire to control invasions. Seeds germinate readily after burning. Fire intensity may be enhanced in invaded areas, potentially damaging native species
Biocontrol	No	No	Candidate pathogens appear to have a large host range and may damage native and agricultural plants

seedling stage), mid-season mowing (carried out before the population flowered), late season mowing (following flowering but before seed set) and mowing the population twice during the season (once in early summer and again in late summer) all resulted in reduced plant biomass and seed production, but late season mowing was marginally more effective in reducing seed production compared to the other treatments.

See Table 1 for a summary of the possible methods to control *M. vimineum*.

Cultural control

Grazing is not considered an option for *M. vimineum* since cattle, deer and goats avoid feeding on the species (Barden, 1991) and if they do consume it they are non-selective.

Flooding for more than 3 months, or intermittent flooding during the growing season, may be an effective control method for mature plants of *M. vimineum* (Barden, 1991). However, the seeds can survive periods of inundation of at least 10 weeks (Barden, 1991).

Controlled burning has been shown to be ineffective at controlling *M. vimineum* as seed will germinate following fires (Tu, 2000). Burning can be of use to clear the amount of litter and plant biomass before herbicide application (Tu, 2000). However, significant health and safety measures should be applied to any control measures using burning.

Disposal

There is no evidence-based information available on the disposal of *M. vimineum* biomass but normal practice should be followed, similar to other species. For example, autoclaving seed and plant material that may contain seed before disposal would be regarded as good practice.

Verification of pest eradication

Mechanical measures and chemical application should be conducted until no sign of *M. vimineum* is found. As the longevity of seed is between 3 and 5 years repeated visits should then be made to managed sites for at least 7 years after all above-ground material has been exhausted.

Appendix 2 – Containment programme

In the case of an established population, eradication may be difficult to achieve. Containment measures aimed at preventing further spread of the pest to endangered areas or to neighbouring countries should be applied. While different approaches have been used to manage *M. vimineum*, no single method alone has proven totally successful and an integrated approach is therefore recommended.

Surveillance

Surveillance should be carried out in likely places of introduction of *M. vimineum*: in riparian habitats, woodlands, damp fields, managed forests, forest plantations and roadside ditches.

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 (see point 2 of Appendix 1). Where feasible, fencing off the contaminated area so as to prevent large mammals (deer etc.) from entering may reduce the natural dispersal of seed.

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

Biological management

At present, no biological controls are available for *M. vimineum.* There is some evidence that indigenous fungal species (*Bipolaris* species and other fungal pathogens) in the invasive range (USA) have switched hosts to *M. vimineum*, acting to reduce the fecundity of infected plants (Flory *et al.*, 2011b) but further research would be needed to test their efficacy and specificity (Kleczewski *et al.*, 2011).