EPPO Datasheet: *Amaranthus palmeri*

Last updated: 2021-02-02

IDENTITY

Preferred name: *Amaranthus palmeri*
Authority: Watson
Taxonomic position: Plantae: Magnoliophyta: Angiospermae: Basal core eudicots: Caryophyllales: Amaranthaceae: Amaranthoideae
Common names: Palmer amaranth (US), careless weed (US), dioecious amaranth
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EPPO Categorization: A2 list, Alert list (formerly)
view more categorizations online...
EPPO Code: AMAPA

more photos...

GEOGRAPHICAL DISTRIBUTION

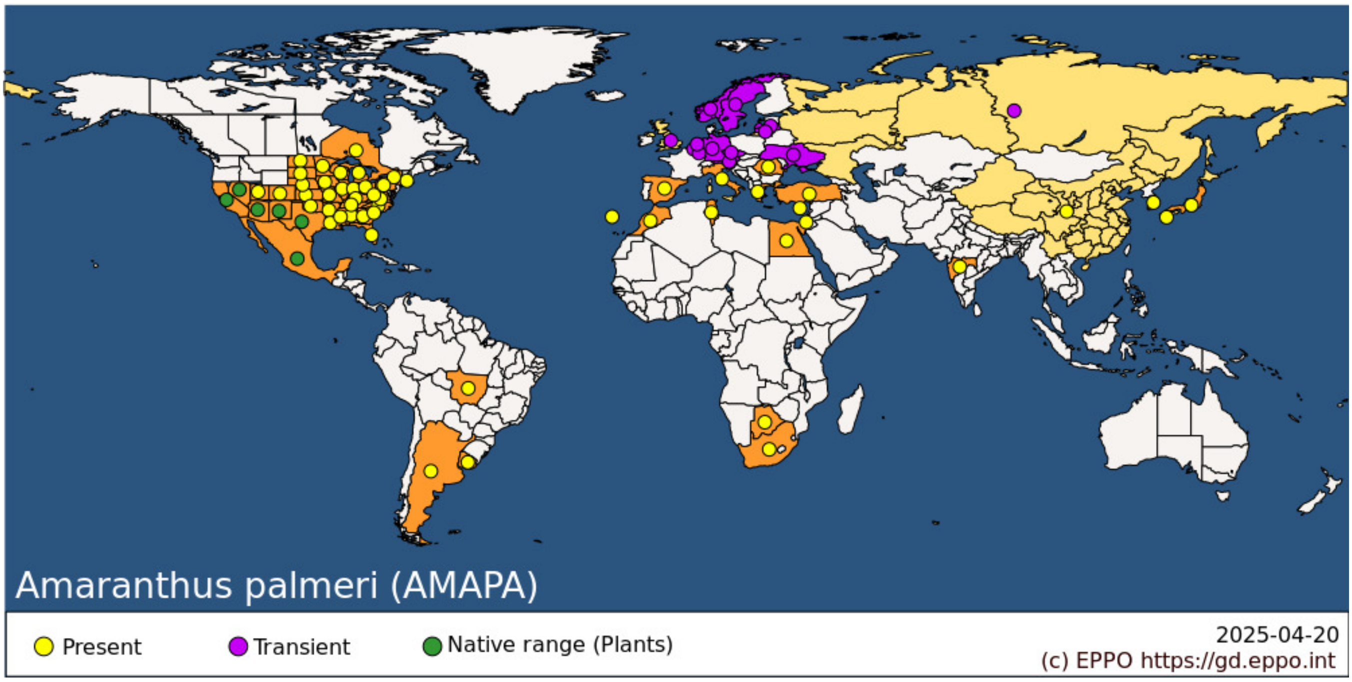
History of introduction and spread

In North America, *A. palmeri* has been historically reported as native to the Sonoran Desert (covering a large part of Southwestern United States and Northwest Mexico) (Sauer, 1955; Mosyakin & Robertson, 1997). In recent decades, it has expanded its range to occupy many states across the USA but is most common and problematic in the southern tier states (Louisiana, Arkansas, Mississippi, Alabama, Florida, Georgia, North and South Carolina). The Canadian Food Inspection Agency (2018) details that the species is considered to be present but highlights the 'significant uncertainty' regarding the current status. It is unknown if populations of *A. palmeri* currently occur in Ontario in areas where it was previously reported. Additionally, both Mosyakin & Robertson (1997) and USDA (2019) report the species as present in Australia but it remains uncertain if the species does occur in Australia.

A. palmeri was first observed in the EPPO region (e.g. in Sweden) in the early 1900s and is now recorded as established in a few EPPO countries and transient in several others. In some countries, occurrences have increased in recent years. For example, in Spain, *A. palmeri* was first found in 2007 dispersed among crop fields (maize) and adjacent field margins. In Arag?n, in 2019, 1467 fields were surveyed and 118 had different degrees of infestation of *A. palmeri* (A. Mari Leon, pers. comm., 2020).

Within the EPPO region, *A. palmeri* has not been shown to have spread significantly in space and time, with the exception, potentially, of the occurrence of the species within Israel. Current spread rates may be due to abiotic limitations that prevent the establishment of the species. Additionally, the species is not commonly found growing in natural habitats within the EPPO region and therefore spread has not been facilitated by natural pathways such as rivers. With climate change, and the potential increase in established populations, spread may increase within the area.

Distribution



EPPO Region: Austria, Belgium, Cyprus, Czechia, Denmark, Germany, Greece (mainland), Israel, Italy (mainland), Latvia, Lithuania, Luxembourg, Morocco, Netherlands, Norway, Portugal (Madeira), Romania, Russian Federation (the), Spain (mainland), Sweden, Tunisia, Türkiye, Ukraine, United Kingdom
Africa: Botswana, Egypt, Morocco, South Africa, Tunisia
Asia: China, India (Maharashtra), Israel, Japan (Honshu, Kyushu), Korea, Republic of
North America: Canada (Ontario), Mexico, United States of America (Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin)
South America: Argentina, Brazil (Mato Grosso), Uruguay

MORPHOLOGY

Plant type

Annual herbaceous.

Description

The following information on the morphology of *A. palmeri* has been taken from the Flora of North America (Mosyakin & Robertson, 1997), Ward *et al*. (2013) and Iamonico (2015).

Stems are erect, branched, usually (0.3–)0.5–1.5(?3) m tall, with many lateral branches often ascending. The central stem is reddish?green. Leaves are long?petiolate; blade obovate or rhombic?obovate to elliptic proximally, sometimes lanceolate distally, 1.5–7 × 1–3.5 cm, base broadly to narrowly cuneate, margins entire, plane, apex subobtuse to acute, usually with terminal mucro. The leaves are green and can have a dark V?shaped chevron on the adaxial surface. Inflorescences are terminal, linear spikes to panicles, usually drooping, occasionally erect, especially when young, with few axillary clusters, uninterrupted or interrupted in proximal part of plant. Bracts: of pistillate flowers with long?excurrent midrib, 4–6 mm, longer than tepals, apex acuminate or mucronulate; of staminate flowers, 4 mm, equalling or longer than outer tepals, apex long?acuminate. Pistillate flowers: tepals 1.7–3.8 mm, apex acuminate, mucronulate; style branches spreading; stigmas 2(?3). Staminate flowers: tepals 5, unequal, 2–4 mm, apex acute; inner tepals with prominent midrib excurrent as rigid spine, apex long?acuminate or mucronulate; stamens 5. Utricles tan to brown, occasionally reddish brown, obovoid to subglobose, 1.5–2 mm, shorter than tepals, at maturity walls thin, almost smooth or indistinctly rugose. Seeds are dark reddish brown to brown, 1–1.2 mm diameter, shiny. However, a lot of variability is observed within *A. palmeri*. Identification of the species should be supported by molecular methods.

A. palmeri has a fibrous root system which extends far from a well?developed taproot (Morichetti *et al*., 2013).

Misidentification between *Amaranthus* species can and has occurred throughout its range due to the morphological variation within species and hybridization between species (Wetzel *et al*., 1999). There are several identification keys that can be used to distinguish between *Amaranthus* species (Pratt *et al*., 1999), and some of the key characteristics include flower morphology (needing magnification identification due to their small size), leaf shape, presence or absence of hair on the stem, seed head shape and seedling shape (Pratt *et al*., 1999).

Seeds of *A. palmeri* are not visually distinguishable from those of all other *Amaranthus* species.

BIOLOGY AND ECOLOGY

General

A. palmeri is a dioecious summer annual species which is frost sensitive (PFAF, 2019) . Even though *A. palmeri* can vary biologically from different populations, plants exhibit phenotypic plasticity driven by the environment which facilitates their spread and persistence in new areas (Spaunhorst *et al*., 2018). The competitive ability of *A. palmeri* may, in part, be attributed to its high photosynthetic rate, which has been cited up to 81 µmol CO_2 $m^{?2}$ $s^{?1}$ at 42°C) (Davis, 2015 citing Ehleringer, 1983).

Seeds are naturally dispersed by barochory (falling from the parent plant) and hydrochory (dispersal via water, as both seeds and fruits can float easily). In the case of barochory, dispersal takes place over very limited distances (a few metres around the mother plant). In the case of hydrochory, Norsworthy *et al*. (2014) reports that *A. palmeri* seed can travel as far as 114 m in rainwater. Seeds can be spread through water movement, along rivers and streams, and throughout a catchment.

Seed bank densities have been estimated to be as high as 1.1. billion seeds $ha^{?1}$ (Menges, 1987). Jha *et al*. (2014) demonstrated that the seedbank in soil will be almost completely depleted in 4 years if no additional seeds are allowed to enter. The depth seed occurs in soil is reported to affect seed viability within the seed bank.

A. palmeri has been shown through field and greenhouse experiments to be capable of hybridizing with *A. spinosus*, *A. tuberculatus* and *A. hybridus* (Gaines *et al*., 2012). Ward *et al*. (2013) suggests that hybridization under field conditions is low and probably rare within the natural environment, especially when consideration is given to the lack of overlap in flowering times between congeners.

A. palmeri has been shown to have developed herbicide resistance to a number of active substances for eight different herbicide mechanisms of action: ALS?inhibiting herbicides (e.g. imazethapyr), auxins (e.g. 2,4?D), tubulin inhibitors (e.g. trifluralin), EPSPS (e.g. glyphosate), HPPD inhibitors (e.g. mesotrione), protoporphyrinogen oxidase (PPO, e.g. acifluorfen), photosystem II (PSII, e.g. atrazine) and VLCFA (e.g. metolachlor) (USDA, 2019a; Heap, 2020). Herbicide resistance can be passed on through gene flow (Ward *et al*., 2013). Resistance has been shown in the USA (cotton, soybean, maize, sorghum, alfalfa, peanut), Argentina (soybean), Brazil (cotton, maize, soybean) and Israel (maize, cotton, watermelon) (Heap, 2020).

Habitats

In its native range, *A. palmeri* is an early successional species colonizing disturbed areas. It is found in natural habitats along permanent or intermittent streams, river flood plains, dried river beds and the edge of marshes (Sauer, 1955). The species is also found in artificial habitats in the United States, including irrigation ditches, roadsides, railways and dumps (Sauer, 1955; Bagavathiannan & Norsworthy, 2016). The species is mainly found in agricultural habitats within fields or along the field margins, capable of invading many summer crops, in particular late sowing crops such as maize and soybean.

Within the EPPO region, the species has been recorded growing along roadsides and cultivated and uncultivated land along roads. It has been reported as growing along canals and rivers in North?East Spain (Verloove & Gullon, 2008) and Northern Italy (Verloove & Argenghi, 2015). Additionally, the species is recorded growing in public gardens, rail networks and areas around ports and industrial premises. Greuter & Raus (2006) detail that the species is found along roads in olive orchards in Greece. In addition, Raab?Straube E, von & Raus Th (2015) observed *A. palmeri* on a road embankment with ruderal vegetation in Northern Italy (Province of Ravenna). The species is also recorded as growing in agricultural habitats in Spain (Recasens & Conesa, 2011). Recent evidence from Arag?n (Spain) from 2019 details that it mainly grows on the edge of the field or in the first lines of the crops (A. Mari Leon, pers. comm., 2020). More than 80% of infested fields were cultivated with maize though *A. palmeri* was also found in orchards, alfalfa, fallow agricultural land and wasteland. In Italy, *A. palmeri* has been recorded in *Glycine max* fields (Fabbri & Campagna, 2016) as well as in many agricultural fields in Israel (Matzrafi *et al*., 2017) mainly in summer crops (e.g. irrigated cotton fields) (J?M Dufour, pers. comm., 2020). In Turkey, the species is reported growing in crop fields close to the roadside, e.g. corn fields (Raab?Straube E, von & Raus Th, 2016).

In Israel, the species is also reported to be present in the following habitats: Mediterranean woodlands and shrublands, deserts, shrub?steppes and semi?steppe shrublands (Flora of Israel, 2019).

Within the EPPO region, most habitats of high conservation value are unsuitable, particularly in Western and Northern Europe. However, this may not be the case for semi?arid habitats in the Mediterranean region, where the species has been shown to establish (e.g. Greece and Israel) in ecological conditions quite similar to its native primary habitats.

Environmental requirements

Seed germination is initiated with availability of moisture, coupled with temperature and light availability (Jha, 2008). *A. palmeri* seeds germinate quickly in the soil, often within 1 or 2 days. The small size of the seeds necessitates a relatively shallow position within the soil profile for successful germination (Ward *et al*., 2013). Guo & Al?khatib (2003) conducted experiments on the effect of temperature on seed germination and did not observe any germination at 15/10°C day/night temperatures. Seed germination was at its peak with 35/30°C day/night temperature. Jha (2008) conducted seed germination experiments using seed collected in South Carolina and showed germination was related to temperature with a time factor.

Steinmaus *et al*. (2000) estimate that the minimum temperature required for development (base temperature) of *A. palmeri* is 16.6°C. Seeds were observed to germinate at a minimal temperature above 15°C in the USA from mid?March to October (November for the unique situation of Florida). *A. palmeri* can persist in very high temperatures. Indeed, at 45/40°C, *A. palmeri* plants only died 25 days after initiation of the heat treatment (Guo & Al?khatib, 2003).

A. palmeri can exhibit a prolonged emergence period throughout the growing season (Davis, 2015), and there can be a number of peak emergence periods throughout the season (Jha, 2008) driven by the timing of rainfalls and moisture periods (e.g. irrigation). There seems to be a physical dormancy based on seed coat thickness which is related to how long the seed remains on the mother plant.

Shading (light quality) of the maternal plant can influence seed germination (Jha, 2008; Ward *et al*., 2013). Additionally, seeds from the middle and top third of the plant have a higher percentage germination compared to seed from the lower third of the plant. (Jha, 2008).

A. palmeri can grow on a wide range of soil types in terms of texture and pH: it grows in light (sandy), medium (loamy) and heavy (clay) soils where it prefers well?drained soils, but can also grow and persist in flooded rice (Norsworthy *et al*., 2013). The pH of preferred soils includes acid, neutral and alkaline soils. It prefers full sunlight to shade (Ward *et al*., 2013).

Natural enemies

Within the EPPO region, there are no host specific natural enemies of *A. palmeri*. Generalist natural enemies will potentially attack the plant, but these are unlikely to inflect enough damage at the population level to influence establishment.

Uses and benefits

There are no known uses or benefits of *A. palmeri* for the EPPO region.

PATHWAYS FOR MOVEMENT

Globally, there have been numerous interceptions of *A. palmeri* as contaminant of seed or as a contaminant of grain (including bird feed). Pheloung *et al*. (1999) lists *A. palmeri* as a weed species associated with maize imported from the USA which are not recorded as present in Australia. In Spain and Romania, indirect evidence suggests the species may have entered via imported grain. The species has been recorded in Andalucía at the port of Sevilla and in Palos de la Frontera (province of Huelva) in the vicinity of industrial premises where grains and plant products are processed. In North?East Spain, the infestation started in an animal fodder factory where probably some *A. palmeri* seeds fell out of a maize or soybean truck (Alicia Cirujeda Ranzenberger, pers. comm., 2020). In 2017 the animal fodder factory was visited by weed scientists who observed at that time several plants growing on the site and some spread had already occurred to the other side of the road, where plants could be seen along the roadside in field boundaries.

Both the Canadian Food Inspection Agency (2018) and the USDA (2019) highlight the movement of *A. palmeri* seed as a contaminant of seed. *A. palmeri* has been identified from certified soybean in seed lots and seed bags in Louisiana (J. Ferrell, pers. comm., 2020). Uncertified commercial seeds from Australia, the USA and Europe (e.g. novel forage seeds) have been demonstrated to harbour seed contaminants, including several *Amaranthaceae* species (Cossu *et al*., 2019).

USDA (2013) details that *A. palmeri* was identified as a contaminant in conservation plantings in Illinois, Indiana, Iowa, Minnesota and Ohio. It was a contaminant in Conservation Reserve Program (CRP) seed mixes. Some native seed mixes planted to foster habitats for honeybees and other pollinators have been found to be contaminated with *A. palmeri* (WSU, 2020). *A. palmeri* was also found in crop pollinator commercial seed mixtures in the USA (Oseland *et al*., 2017). Additionally, seed mixtures for conservation, pollination and seed mixtures for forage plants for mammals for hunting (e.g. see https://www.plantbiologic.com/products/last?bite?food?plot?seed) will be placed directly in habitats that can be suitable for *A. palmeri*.

Seed of *A. palmeri* may become a contaminant of machinery and equipment. However, there is probably very little movement of used machinery from the countries where the pest occurs into the EPPO region and if there is, it is probable that such equipment would undergo phytosanitary procedures such as decontamination (e.g. in the EU, Regulation (EU) 2019/2072).

IMPACTS

Effects on plants

A. palmeri with its rapid growth rate and ability to accumulate large quantities of biomass is very competitive and has also an advantage with its long roots. In the USA, *A. palmeri* is considered a significant weed in agricultural systems (Ward *et al*., 2013). Major impacts have been reported in soybean, peanut, corn and sweet potato and the plant has become one of the most economically damaging weed species in the USA. Lindsay (2017) provides estimates of the potential economic impacts of the species as a result of reduced crop yields. The economic losses by producers in the mid?southern states of the USA for 1 year (2015) could equate to 250 million USD for cotton, 1.3 billion USD for maize and 2.5 billion USD for soybean, without including weed management costs.

A. palmeri has in recent years been ranked as the most troublesome cotton weed in the southern USA. In 2014, at least 300 000 ha of cotton (*Gossypium hirsutum*) were reported as invaded by the weed in Arkansas, and over one million acres in Georgia. In the USA, *A. palmeri* densities of 1 and 10 plants per m^2 reduced cotton yields by 11% and 59%, respectively (Ward *et al*., 2013 citing Massinga *et al*., 2001). In cotton, the presence of *A. palmeri* doubled to quadrupled harvest time compared to a weed free field. Equipment can even be damaged if densities of *A. palmeri* are higher than 0.65 plants per m^2.

Up to 91% reduction in yield has been reported in maize (*Zea mays*) in Kansas with an *A. palmeri* density of 10.5 plants per m^2 (Massinga *et al*., 2001). Just 0.66 *A. palmeri* plants per m^2 can result in yield losses of 11%. The maximum predicted soybean *Glycine max* loss was 79% from full season interference of *A. palmeri* (density of 10 plants per m^2). At just 0.33 plants per m^2, yield loss was 17% (Klingaman & Oliver, 1994). Losses in peanut crops have been reported at 28% and 68% with *A. palmeri* densities of 1 and 5 plants per m^2 (Burke *et al*., 2007).

Meyers *et al.*, (2010) details that *A. palmeri* can reduce the quality and quantity of sweet potato (*Ipomoea batatas*). Ward *et al*. (2013) states 'The highest grade of sweet potatoes, 'Jumbo', is reduced 56% and 94% from Palmer amaranth [*A. palmeri*] densities of 0.47 and 6.13 plants m^2, respectively, with 'marketable' grade reduced 36 and 81% at these densities (Meyers *et al*., 2010). The threshold density of Palmer amaranth [*A. palmeri*] that is equivalent to 10% yield loss is 0.08 plants per m^2, or one plant every 12.5 m^2'. Moore *et al*. (2004) details sorghum (*Sorghum bicolor*) yield losses between 38% and 63% near Chichasha Oklahoma with *A. palmeri* density of 1.58 plants per m. The presence of *A. palmeri* had a negative effect on the drying of the crop, which could act to delay the harvesting of sorghum seed. *A. palmeri* has been shown to have negative impacts on watermelon yield and marketable fruit numbers. Four *A. palmeri* plants per planting hole was shown to reduce marketable yield by 41%, 38% and 65% for the varieties Exclamation, Carnivor and Kazako, respectively (Bertucci *et al*., 2019).

In addition to direct interference with the crop, *A. palmeri* can affect crops in a non?competitive way. *A. palmeri* may also suppress crop growth through allelopathy. Experiments indicate that incorporation of a heavy stand of *A. palmeri* into the soil just before planting can hinder seedling growth in carrot, onion, cabbage and sorghum.

Infestation with *A. palmeri* can also have an impact on trade and in the USA, *A. palmeri* is classified as a noxious weed species in a number of states which imposes phytosanitary requirements (inspections) on commodities that can be contaminated by the seed (e.g. grain and seeds for planting). This can have an impact on trade and incur costs related to delays and inspections (see USDA, 2019a). Following the interception by China of *A. palmeri* with other pests in canola grains from Canada, the export permit from two Canadian companies (Canada's largest grain processors) was revoked which had a major economic impact (China buys 40 per cent of Canada's canola exports, roughly 3.6 billion CAD). The price of the active canola contract has fallen to 455 CAD a tonne in March 2019, its lowest level since 2016. Other Canadian companies remain eligible to export canola grains to China but these imports are subject to enhanced inspections, including increased testing (WTO, 2019), which is costly. This import ban led to a communication by Canada to the SPS Dispute Settlement body (WTO, 2019).

Within the EPPO region, *A. palmeri* occurs already as a weed in different crops (e.g. maize, cotton and soybean). In Turkey, the species has been reported as showing 'extremely aggressive' behaviour [invasive behaviour] (Raab?Straube E, von & Raus Th, 2016) and locally to be a weed in cotton and maize (Özaslan *et al*., 2017). Likewise, in Spain, the species invaded crop fields (Recasens *et al*., 2018) with some fields already infested with a high density of *A. palmeri* (Alicia Cirujeda Ranzenberger, pers. comm., 2020). In Israel, *A. palmeri* is found throughout the country in crop fields (cotton, watermelon, maize) and herbicide resistance has already been shown in these crops (Matzrafi *et al*., 2017; Flora of Israel Online, 2019; Heap, 2020).

Kistner & Hatfield (2018) highlight that climate change will be beneficial to the species in Europe where regions suitable for casual populations may become suitable for established populations. Such effects may act to increase the area available for establishment in the EPPO region where negative impacts on agriculture systems may be seen.

Environmental and social impact

There is no data for negative impacts of the species on native biodiversity in the EPPO region. Within the EPPO region, the species mostly grows in ruderal or managed habitats with relativity low biodiversity value (e.g. Germany; U. Starfinger, pers. comm., 2020).

A. palmeri can hybridize with other *Amaranthus* species, thus adversely affecting the gene pools of other species. Hybridization is also a route by which herbicide resistance can be moved between different *Amaranthus* spp. (Costea *et al*., 2001). However, native European *Amaranthus* species are monoecious (Steckel, 2007) and are not expected to hybridize in field conditions with *A. palmeri* when present in a limited number.

CONTROL

A pro?active and integrated weed management strategy will be required to effectively manage *A. palmeri* in agricultural systems. Heavy tillage, as opposed to light soil disturbance, at the beginning of the season will prepare a proper seedbed for crop planting and eliminate all weeds that have emerged up to this point. Following planting, interrow cultivation can assist to eliminate small seedlings from establishment. In general, significant soil disturbance from heavy tillage discourages the small?seeded dicots such as *A. palmeri*.

Planting dense cover?crops can help suppress *A. palmeri* germination and emergence. In general, grass cover?crops (such as wheat, rye, barley) can be killed with herbicides 2–6 weeks prior to summer crop planting. The summer crop can then be planted directly into the killed cover crop. Rolling the cover?crop flat and then planting the summer crop in the same direction as rolling will provide even greater mulch on soil surface to suppress weed growth. However, if the cover?crop is not dense, the level of weed suppression will be reduced or non?existent.

Planting crops with different agronomic life cycles (e.g. winter crops), places *A. palmeri* at a disadvantage to germinate and survive. Moreover, this can allow a greater variety of herbicides and other weed management strategies to be used.

Herbicides can be an important component of an integrated weed management plan. However, they must be applied in a timely and proactive manner. Allowing plants to emerge and reach 10–15 cm in height will greatly complicate management with herbicides. Multiple applications of herbicides are necessary to control *A. palmeri*.

It should be noted that in natural environments, management practices should be tailored to the habitat invaded.

REGULATORY STATUS

In the EPPO region, *A. palmeri* is included on the EPPO A2 list of pests recommended for regulation as a quarantine pest.

In the USA *A. palmeri* is not regulated at the federal level but it is considered a noxious weed in the states of Delaware, Minnesota and Ohio (Hensleigh & Pokorny, 2017). It is subject to seed restrictions in Indiana, Iowa, Minnesota, North Dakota, Ohio, South Dakota, Tennessee, Washington and Wisconsin (USDA, 2019b).

In Canada, *A. palmeri* is not regulated at the federal level but it is regulated as a noxious weed in the province of Manitoba (Canadian Food Inspection Agency, 2018).

In Brazil, *A. palmeri* is regulated at import for several host seeds and grains from various locations which are required to be free from the pest demonstrated by either the production in a pest?free area, a phytosanitary inspection at the place of production or laboratory testing (WTO, 2018: WTO notification G/SPS/N/BRA/1369).

In Australia, *A. palmeri* is a quarantine species which is prohibited from entry (Pheloung *et al*., 1999; Moniodis, 2014; BICON, 2019; cited in USDA, 2019a).

PHYTOSANITARY MEASURES

EPPO (2020) recommends phytosanitary measures for grains and seeds for relevant crops. Grains of *Arachis hypogaea*, *Glycine max*, *Helianthus annuus*, *Oryza sativa*, *Sorghum bicolor* and *Zea mays* should be produced in a pest free area, or found free from *A. palmeri* after inspection for and testing of *Amaranthus* seeds, or should have been devitalized according to an appropriate method. Measures for grains should apply to all commodities that contain the species specified, i.e. irrespective of whether they are intended for animal feed (including bird seeds), human consumption or processing.

Seeds of *Glycine max*, *Gossypium hirsutum*, *Helianthus annuus*, *Oryza sativa*, *Sorghum bicolor* and *Zea mays* should be produced in a pest?free area or found to be free from *A. palmeri* after inspection for and testing of *Amaranthus* seeds.

Seed mixtures and native seeds should have been produced in a pest?free area or found to be free from *A. palmeri* after inspection for and testing of *Amaranthus* seeds.

New associated crops should be added if *A. palmeri* is shown to develop in these crops and if their seeds or grains may present a risk of contamination with *A. palmeri* seeds.

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