European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes

Data sheets on quarantine pests
Fiches informatives sur les organismes de quarantaine

Solanum elaeagnifolium

Identity

Scientific name: *Solanum elaeagnifolium* Cavanilles
Synonyms: *Solanum dealbatum* Lindley, *Solanum flavidum* Torrey, *Solanum hindsianum* Bentham, *Solanum leprosum* Ortega, *Solanum roemerianum* Scheele, *Solanum saponaceum* Hooker fil in Curtis, *Solanum texense* Engelman & A. Gray, *Solanum uniflorum* Meyer ex Nees
Taxonomic position: Solanaceae
Common names: Silver-leaf nightshade, white horse-nettle, tomato weed, silverleaf nettle, bitterleaf nightshade, bitter apple, silverleaf bitter apple, bull nettle, prairie berry (English); morelle jaune (French); ölweidenblättriger, nachtschatten (German); meloncillo del campo, quillo-quillo, revienta caballo, tomatillo, trompillo (Spanish); Tähtikoiso (Finnish); паслёи линейнолистный (Russian); bitterappel, bloubos, satansbos, silwerblaarbitterappel (Afrikaans); chouka assafra, chouika, chouk jmel, hassika matechat jmel, zririga (in Morocco)
Notes on taxonomy and nomenclature: The name *Solanum elaeagnifolium* is universally accepted, though the species displays considerable morphological variation, especially in the Americas, confusing its taxonomic status. Morton (1976) proposed that the Argentine form was a separate subspecies, but Symon (1981) concluded that this form also occurs in North America and is thus a natural variant of the same species. Several varieties and forms have been described, though clonal reproduction permits the coexistence of different variants, suggesting that classification at the varietal level should be avoided unless genetic differences are confirmed (Stoltsz, 1994; Heap & Carter, 1999)
EPPO code: SOLEL
Phytosanitary categorization: EPPO A2 List no. 342

Geographical distribution

EPPO region: Algeria, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Republic of Macedonia, Morocco, Serbia and Montenegro, Spain, Syria, Tunisia
Asia: India (Karnataka, Tamil Nadu), Israel, Taiwan
Africa: Algeria, Egypt, Lesotho, Morocco, South Africa, Tunisia, Zimbabwe
North America: Mexico, USA (Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, Nebraska, Nevada, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, South Carolina, Tennessee, Texas, Utah, Washington)
Central America and Caribbean: Guatemala, Honduras, Puerto Rico
South America: Argentina, Chile, Paraguay, Uruguay
Oceania: Australia (all states).

History of introduction and spread

S. elaeagnifolium is native to north-east Mexico and south-west USA where it is a weed (Robinson *et al*., 1978). It is also considered native to Argentina, the nature of the insect herbivorous fauna suggesting that this distribution is secondary. It has been introduced to other parts of North America including California and Florida and is now widespread in all but the Great Lakes and New England regions (USDA-NRCS, 2005). Invasions of the weed have also occurred in Australia, southern India, South America, southern Africa and around the Mediterranean Basin. Further spread is very likely. It was newly recorded in southern Taiwan and the Penghu Islands in 2002 (Hsu & Tseng, 2003). It is reported but unconfirmed in Turkey.

Introduction to Morocco is believed to have resulted from the import of contaminated crop seeds in 1958 (Tanji *et al*., 1984), and it now infests 50 000 ha in the Tadla region and it is spreading to other regions such as El-Kelâa des Sraghna and Marrakech. In South Africa, it is thought to have been imported as a contaminant of pig fodder around 1905 (Wassermann *et al*., 1988), and/or hay during the 1940s or 1950s, being recorded as a problem in 1952 and declared a weed in 1966. Similarly, infestations in South Australia are linked to imports of contaminated hay from North America during the 1914 drought, although the weed was first recorded in New South Wales in 1901 and then in Victoria in 1909 (Heap *et al*., 1997). Later infestations in Western Australia appeared from contaminated Sudan grass (*Sorghum sudanense*) introduced from eastern Australia (Heap & Carter, 1999). In the USA, where the plant is native to some south-western States, contaminated ballast and bedding used in railway cattle wagons led to the introduction of the weed into California in 1890 (Goeden, 1971).

Morphology

Plant type

S. elaeagnifolium is a seed- or vegetatively-propagated (therophyte, chamaephyte, hemicryptophyte or geophyte), broadleaved herbaceous and woody perennial.

Description

S. elaeagnifolium is multistemmed, up to 1 m tall, the aerial growth normally dying back during winter, with an extensive root system spreading to over 2 m deep (Fig. 1). The term 'rhizome' cannot be used in the case of this plant as fragments on any part of the roots can regenerate.

Stems are cylindrical, sparingly branched, with a few scattered reddish prickles, herbaceous except at the base.

Leaves are dark green to pale greyish green, petiolate, lanceolate, obtuse or acute at the tip, rounded or truncate at the base, with entire or wavy margin, 2.5–10 (max 16) cm long and 1–2.5 (max 4) cm wide, petiole 0.5–2 cm long, sometimes slightly lobed or with undulate margins (Figs 2 & 3). Leaves, stems and calyx are densely pubescent, giving the plant its typical silver-green appearance. Foliage is covered with star-shaped hairs. Yellow- to brown-coloured prickles usually occur on the stems and also the main veins of the leaves.

The inflorescence is a solitary cyme of 1–7 flowers, with long peduncles (5–20 mm). The calyx measures 5–7 mm, with 2–4 linear lobes. The corolla is 25–35 mm large and is orbicular, generally bright blue to purple but sometimes white with yellow anthers of 7–9 mm (Fig. 4).

The fruit is an irregularly dehiscent berry, initially spherical, green (with white patches) and fleshy, drying and becoming yellow to orange (10–15 mm in diameter) at maturity (Fig. 5). A single plant generally produces 40–60 fruits, each containing

Fig. 2 *S. elaeagnifolium* seedling. Surroundings of Kairouan, Tunisia, May 2006. Photo: Sarah Brunel.

Fig. 3 *S. elaeagnifolium* invading a potato field. Surroundings of Kairouan, Tunisia, May 2006. Photo: Sarah Brunel.

Fig. 1 Extensive root system of *S. elaeagnifolium*. Berre l'Etang, Bouches-du-Rhône, France, April 2005. Photo: Christelle Chevrat.

Fig. 4 *S. elaeagnifolium* inflorescence in a wheat field. Surroundings of Kairouan, Tunisia, May 2006. Photo: Sarah Brunel.

Fig. 5 Fruit of *S. elaeagnifolium*. Surroundings of Kairouan, Tunisia, May 2006. Photo: Sarah Brunel.

Fig. 6 *S. elaeagnifolium* invading an olive orchard. Surroundings of Kairouan, Tunisia, May 2006. Photo: Sarah Brunel.

60–120 seeds, smooth, flat, greenish-brown, 2–3 mm in diameter, closely resembling those of tomatoes.

Invasions of croplands and pastures by *S. elaeagnifolium* are most conspicuous during midsummer when the plants are flowering (Fig. 6). In such infestations, the plants are easily identified by the abundance of blue or purple flowers and the orange-yellow mature berries that appear later in the season.

Similarity to other species

In the EPPO region, *S. elaeagnifolium* is very distinct from other native or introduced *Solanum* spp. Elsewhere in the world, it has been confused with *S. coactiliferum*, *S. esuriale* and *S. karsensis* in Australia (Heap *et al*., 1997; Heap & Carter, 1999), *S. carolinense* in Texas, USA (Gorrell *et al*., 1981), and *S. panduriforme* in South Africa where hybrids have also been identified (Wassermann *et al*., 1988). However, variation within introduced populations is considered to be the result of multiple introductions rather than hybridization with native *Solanum* species (Stoltsz, 1994; Heap *et al*., 1997). (See Notes on taxonomy and nomenclature, above.)

Biology and ecology

General

S. elaeagnifolium is a perennial geophyte with roots, summer-growing, dying back in late autumn, and surviving off its rootstocks during the winter.

It has four different growth forms: from seeds (as a therophyte) germinating from spring through summer; from buds above soil level giving new shoots in spring (chamaephyte); from buds at the soil surface (hemicryptophyte); from buds buried in the soil, which regenerate from its roots (horizontal or vertical), from which new shoots arise (geophyte).

It mainly reproduces vegetatively, from buds on underground fragments. Fragments as small as 0.5 cm long and as deep as 20 cm deep can regenerate. Sections of taproot may maintain their viability for up to 15 months (Molnar & McKenzie, 1976). Ten-day-old seedlings are able to regenerate. Sprouting is enhanced by the removal of the aerial parts of the parent plants or by cultivation. This aggressive vegetative growth from deep rootstocks makes *S. elaeagnifolium* very difficult to control, both mechanically and chemically.

Reproduction by seed is secondary, though seeds are highly viable and last at least 10 years in soil. High levels of dormancy and infrequent germination can lead to the establishment of extensive viable seed banks.

Studies indicate that 10% of seed is still viable after passing through the digestive tract of sheep (Washington State Noxious Weed Control Board, 2006). Seeds require fluctuating temperatures to germinate. Boyd & Murray (1982) obtained a maximum germination rate of 57% when they germinated seeds at 20°C for 16 h and at 30°C for 8 h; light and darkness had no effect. They also found that a pH of 6 or 7 was optimal for germination. Other work indicates that immersing seeds in running water for relatively long periods may improve germination rates (Rutherford, 1978). Factors controlling seed germination are poorly understood, however, the reproductive biology of *S. elaeagnifolium* is comprehensively reviewed by Heap & Carter (1999), Parsons (1981) and Richardson & McKenzie (1981).

The life cycle of the plant is composed of 5 phases: vegetative regeneration and germination during spring; vegetative development, the duration of which depends on the biotope; flowering

Fig. 7 An infestation of *S. elaeagnifolium* on a roadside, probably introduced with the growing media of the ornamental plant. Surroundings of Kairouan, Tunisia, May 2006. Photo: Sarah Brunel.

from spring to the end of summer and fructification from the end of spring until autumn.

Pollination is believed to occur via insects. Individual plants produce up to 200 berries per growing season, approximating to 1500–7200 seeds per plant. Factors influencing seed ecology, viability and germination are comprehensively reviewed by Heap & Carter (1999), who report the chromosome number of *S. elaeagnifolium* as 2n = 24.

Habitat

S. elaeagnifolium is mainly a weed of cultivated land, orchards, managed grasslands and associated man-made habitats such as natural grasslands, riverbanks/canalsides, rail/roadsides and wastelands (Fig. 7). It appears to be adapted to a wide range of habitats and soil conditions, but appears mostly in areas of relatively low annual rainfall (250–600 mm) (Parsons, 1981; Heap & Carter, 1999). In Australia and South Africa, the largest infestations occur in cropping and grazing land, with smaller infestations found in irrigated pastures, orchards and vineyards, roadsides, channel banks and stockyards (Wassermann *et al*., 1988; Heap & Carter, 1999). In particular, the weed thrives on disturbed land and although undisturbed pastures and natural vegetation are not normally invaded, this is facilitated by trampling caused by livestock.

Environmental requirements

S. elaeagnifolium tolerates Mediterranean, steppe and mild climates with relatively high summer temperatures and low annual rainfall (Parsons, 1981; Heap *et al*., 1997). It has been suggested that cool summers and high annual rainfall are factors that could prevent invasion in certain areas (Heap & Carter, 1999) and this is consistent with the distribution of the weed in Australia and South Africa. However, in Europe, its northern potential limit may be more dependent on winter temperatures. Established plants are sensitive to frost and waterlogging but are tolerant to saline conditions and highly resistant to drought (Wassermann *et al*., 1988). Full sunlight is most favourable for growth, and shading reduces plant vigour. It requires high temperatures (20–34°C) for normal germination and growth. Germination is advanced under favourable moisture conditions, notably heavy rains, and by alternating temperatures. Once established, the plants are highly resistant to drought and are widespread in semiarid areas, but will also thrive under irrigated conditions in these areas. Although summer-growing, the weed is very adaptable climatically and, in Australia, also occurs in winter rainfall areas (Cuthbertson *et al*., 1976). It is recorded at up to 1200 m altitude (Californian Department for Food and Agriculture, 2006).

S. elaeagnifolium can adapt to different soil types. For example, in Australia, the heaviest infestations were observed on sandy soils with low organic matter (Heap & Carter, 1999).

Climatic and vegetational categorization

S. elaeagnifolium is found in areas with a hot dry summer and a cool wet winter. In its native range, it seems hardy only to zone 9 (–7 to –1°C) but as a weed it is hardy to zone 6 (–23 to –18°C) as, for example, in the USA. It is associated with the following vegetation zones: Mediterranean sclerophyllous forests and temperate steppes.

Uses and benefits

Despite its confirmed adverse toxicity to livestock (e.g. Dollahite & Allen, 1960; Molnar & McKenzie, 1976), South African cattle and wild antelope browse *S. elaeagnifolium* during spring and early summer with no ill effects (Wassermann *et al*., 1988), and the plant has also been pelleted and successfully fed to livestock. The steroidal alkaloid Solasodine used in the preparation of contraceptive and corticosteroid drugs has been commercially extracted from *S. elaeagnifolium* berries in India (Maiti, 1967) and Argentina, making it the most promising source among *Solanum* species investigated (Heap *et al*., 1997). Recent studies have identified other potential uses for *S. elaeagnifolium* as plant extracts have shown moluscicidal and nematicidal activity, as well as cancer-inhibiting activity.

Pathways of movements

Natural dispersal

Spread can occur both vegetatively from cut root sections, and via seeds. The fruit can float, and can be dispersed over long distances along rivers and streams, especially during floods. Seeds are also easily and widely dispersed by agricultural machinery and tools, vehicles, in bales of hay and alfalfa, and in the dung of livestock and wild animals. Although the plants die back in winter, ripe fruit are retained on dead branches and may be dispersed by wind. Dried plants may also blow like tumbleweeds, spreading seed along the way (Boyd *et al*., 1982). *S. elaeagnifolium* has a particular pattern of spreading. From the first point of introduction and establishment, the plant spreads in all directions. This spreading is not continuous but occurs in leaps. The space between the neighbouring colonies increases with distance from the centre (Yannitsaros *et al*., 1974).

Agricultural practices

Spread is possible by livestock and manure, irrigation water, agricultural machinery, rooted nursery plants, contaminated straw or seeds. Vehicles and tools used in agriculture, bulldozers and other earth-moving equipment can also spread the weed by transporting both seeds and sections of root. Soil, sand and ornamental plants can be contaminated by fragments of roots or seeds of *S. elaeagnifolium* (Taleb *et al*., 2007).

Movement in trade

S. elaeagnifolium has no ornamental value and has only occasionally been introduced for its aesthetic characteristics (Chalghaf *et al*., 2007), thus introductions worldwide appear to have been unintentional. Movements of contaminated fodder are proposed as the mode of introduction into South Africa and Australia, where it is suspected that multiple, rather than single, introductions have occurred. Crop seed, notably grain and fodder crops that are contaminated by the weed, are another major source of infestation (e.g. in Australia, Morocco, South Africa and California). The main crops reported to have contained *S. elaeagnifolium* are maize (*Zea mays*) and lucerne (*Medicago sativa*).

Impact

S. elaeagnifolium has a negative impact mainly on crop production but also on livestock production, on the environment and on trade and international relations.

Effects on plants

By being a spring species, the life cycle of *S. elaeagnifolium* perfectly coincides with those of spring crops. In autumnal crops, the invasive plant is only present during the second half of their life cycle.

S. elaeagnifolium competes for moisture and nutrients with many crops. The most affected crops are *Gossypium hirsutum* (Cotton), *Medicago sativa* (lucerne), *Sorghum bicolor* (common sorghum), *Triticum aestivum* (wheat), *Zea mays* (maize) and to a lesser extent *Arachis hypogaea* (groundnut), *Asparagus officinalis* (asparagus), *Beta vulgaris* var. *saccharifera* (sugar beet), *Citrus* spp. (citrus), *Cucumis sativus* (cucumber), *Lycopersicon esculentum* (tomato), *Olea europaea* subsp. *europaea* (olive), *Prunus persica* (peach), *Solanum tuberosum* (potato), *Sorghum sudanense* (Sudan grass) and *Vitis vinifera* (grapevine). Infestations are more serious in drylands, although irrigated croplands are also very prone to invasion, and many other horticultural and orchard crops are affected.

In Morocco, losses of up to 64% in maize without treatment (Baye & Bouhache, 2007) and 78% in cotton have been reported. In Australia, wheat losses varied from 12 to 50% (Cuthbertson, 1976) according to climatic conditions and weed density, but were highest at dry, sandy sites or during low rainfall years (Heap & Carter, 1999). In the USA, sorghum and cotton yield losses under optimal moisture regimes were 4–10% and 5–14%, respectively (Robinson *et al*., 1978), with 75% losses in cotton grown under semiarid conditions.

S. elaeagnifolium also displays allelopathic effects, especially in cotton fields (Californian Department for Food and Agriculture, 2006; Bothma, 2002). Both perennial and annual pastures are adversely affected, with pasture establishment delayed and pasture production reduced.

As a perennial weed, *S. elaeagnifolium* is very difficult to control, and often disrupts tillage and harvesting practices. It can block drains and irrigation channels. Severe infestations could even limit the types of crop that could be successfully cultivated in the USA (Davis *et al*., 1945). The presence of *S. elaeagnifolium* can lead to less effective land usage, reduced monetary returns, and increased production costs arising from control operations.

In California, *S. elaeagnifolium* has been reported as a reservoir for *Lettuce chlorosis virus* (McLain *et al*., 1998) which is transmitted by *Bemisia tabaci*. It is also recorded as a secondary host of several insect pests, the most important being *Leptinotarsa decemlineata* (Hare, 1990), *Anthonomus eugenii* (Patrock & Schuster, 1992), *Globodera rostochiensis* and *Globodera pallida*. In Tunisia, the plant has been reported as a potential source of *Potato virus Y* (PVY) propagation (Boukhris-Bouhachem, 2007).

The berries of *S. elaeagnifolium* are toxic to livestock, particularly when mature (Burrows *et al*., 1981). Symptoms include excessive salivation, nasal discharge, respiratory complications, bloating, trembling and diarrhoea (Parsons, 1981). The plant affects horses and causes mortality to sheep (Molnar & McKenzie, 1976) while goats are apparently unaffected (Parsons, 1981; Wassermann *et al*., 1988).

Environmental and social impact

Although *S. elaeagnifolium* is primarily associated with cultivated land, it may also invade adjoining areas (e.g.

roadsides, river- and canal-sides). It may replace natural vegetation in areas of overgrazed rangeland and in heavily trampled areas around waterholes. However, the environmental impacts are limited in comparison to the impacts on cultivated lands.

Agricultural land infested with *S. elaeagnifolium* loses considerable rental and resale value. In Morocco, the value of infested fields decreased by 25% (Gmira *et al*., 1998). In the USA, farms have been abandoned because of infestation (Parsons, 1981).

Summary of invasiveness

S. elaeagnifolium has been introduced from North America to Africa, Asia, Australia, Europe and South America where it is an important weed of croplands and pastures, mostly in cultivated land, disturbed areas and overgrazed areas with low rainfall. The invasiveness is aggravated by high seed production and an extensive root system that promotes vegetative multiplication and renders conventional control methods very difficult. Other negative effects include hindering commercial cropping activities, harbouring agricultural pests, being toxic to livestock and reducing land values. The plant is officially declared as a noxious weed in several countries.

Control

Cultural control

S. elaeagnifolium is very difficult to control and it is essential to keep it out of uncontaminated areas. Any isolated plants and small patches should be treated as soon as they appear (Parsons, 1981). In endangered areas, regular inspections during midsummer when plants are flowering and vigilance during harvesting are recommended (Heap *et al*., 1997). Grain and fodder crops harvested in contaminated areas should be inspected for contamination. It is also recommended to check hay for *S. elaeagnifolium* berries before feeding it to cattle. This will prevent livestock poisoning and the introduction of seeds into uninfested areas (Californian Department for Food and Agriculture, 2006). In Australia, movements of livestock, mainly sheep, account for most new infestations and stock from infested areas should be quarantined for 14 days to allow all seed to pass through the digestive tract and thus prevent further spread (Heap *et al*., 1997). Unauthorized vehicles should also be kept out of infested properties, and vehicles and machinery should be thoroughly checked for berries and root fragments and cleaned on leaving infested areas. The development of *S. elaeagnifolium* is reduced in irrigated crops and where dense crop stands can be maintained (e.g. with lucerne). It is also controlled by intensive cropping in wheat-sorghum-wheat rotations and by sowing *Eragrostis curvula* in pastures. Viljoen & Wassermann (2004) studied the suppression of *S. elaeagnifolium* by three pasture species under dryland conditions in a field trial. They showed that *Medicago sativa* and particularly *Digitaria eriantha* have the potential to suppress *S. elaeagnifolium* provided that dense stands be achieved and maintained. Although intensive browsing by cattle is reported to reduce fruit set (Wassermann *et al*., 1988), the removal of all cattle from infested pasture is recommended as selective grazing increases the dominance of the unpalatable *S. elaeagnifolium*.

The use of seed free from *S. elaeagnifolium* and deep ploughing at the beginning of summer are recommended as preventative measures.

Mechanical control

In winter crops, regular tillage during the preceding summer weakens *S. elaeagnifolium* because of its lack of growth in winter. In summer crops (e.g. cotton, sorghum), dense crops may suppress the weed and regular tillage or clearing prevent fruit set (Davis *et al*., 1945). Small infestations may be hand-pulled, but this should be repeated several times during the growing season. The plant has sharp spines and gloves should be worn for hand-pulling.

Eradication action has been undertaken in the south of France (Agence Méditerranéenne de l'Environnement, 2006). The entire root system of the plant was taken out, and contaminated ground in the surroundings of the plant buried in a hole three metres deep. In cases of mechanical control, all parts of the plant, including the roots, have to be collected and destroyed. Considering the viability of seeds, monitoring of the treated area should last for at least 10 years.

Control methods in Morocco are reviewed by Ameur *et al*., 2007.

Chemical control

Experience in South Africa (Wassermann *et al*., 1988) and Australia (Parsons, 1981; Heap *et al*., 1997) has shown that *S. elaeagnifolium* is generally very difficult to control with herbicides, including soil sterilants and nonselective chemicals. None were considered effective and affordable for large infestations. Spot-spraying treatments with picloram proved effective in Australia and Greece, whereas glyphosate was unreliable and others less effective (Eleftherohorinos *et al*., 1993; Heap *et al*., 1997). Herbicides were considered to be more effective when applied during optimal moisture conditions and during the 'green berry' stage of the weed (Stubblefield & Sosebee, 1986).

Many experiments have been conducted in Morocco. Zaki *et al*. (1995) showed a significant density and biomass reduction of *S. elaeagnifolium* with the application of glyphosate added with ammonium sulphate at the flowering and fructification stages, followed by mowing 2, 3 or 4 weeks after treatment. The combination of glyphosate and mechanical control allowed a reduction of density (> 92%), biomass (> 94%) and fruit production (100%) of *S. elaeagnifolium*.

Baye *et al*. (2007) found that systemic herbicides such as glyphosate, sulfosate and amitrole have shown to be very effective and are principally recommended for nonselective treatments in orchards (olive, citrus, fruit trees) and fields at postharvest (cereals, sugar beet, market gardening). These require special application conditions and are recommended above all in cases of severe infestation. Phenoxy herbicides, imazapyr and bromacil are used for weed control on roadsides, whether forested or nonforested and possibly on unused plots. Bromacil can be used in citrus orchards that are at least four years old, but only in heavily infested areas in view of its high cost.

Biological control

S. elaeagnifolium supports a diverse insect herbivorous fauna in its area of origin (Goeden, 1971), some of which have been tried as biological control agents notably in South Africa (Olckers & Zimmermann, 1991) and Australia (Wapshere, 1988). Two leaf-feeding beetles, *Leptinotarsa texana* and *Leptinotarsa defecta*, are established in South Africa following release in 1992, though only *L. texana* causes considerable damage, by reducing growth and fruit production (Hoffmann *et al*., 1998; Olckers *et al*., 1999). Morocco has more recently expressed an interest in importing these biological control agents (Klein, 2001). Sforza and Jones (2007) state that biological and impact studies of *Leptinotarsa* spp. in Europe should be conducted. The native leaf-galling nematode *Ditylenchus phyllobius* has been used with some success in the USA (Northam & Orr, 1982). It has become established in India, probably after having been introduced with the plant. It was considered as a biological control agent in South Africa, but was not released due to doubts about its host specificity (Olckers & Zimmermann, 1991). A foliar nematode, *Orrina phyllobia*, which causes leaf and stem galling has also been studied (Roche, 1991). Nevertheless, biological control can only be considered as one component of an integrated management plan, to be used in conjunction with specific management practices.

Regulatory status

S. elaeagnifolium has accidentally been introduced into several countries via contaminated fodder crops. Consignments of seeds, containers and packing material, plants for planting with soil, soil as a consignment, soil as a contaminant, and livestock also present a high phytosanitary risk for the countries that import these products from infested countries. *S. elaeagnifolium* is declared invasive in several countries, including Morocco where it is considered as the country's most noxious weed (Taleb, 2006) and is under official control. In Belarus, Russia and Ukraine where it is a quarantine pest, grain consignments are required to be free from its seeds. This plant is also included in lists of plants controlled under noxious weed legislation in Australia, South Africa and approximately 20 states of the USA (USDA-NRCS, 2005). Moreover, the sale of contaminated agricultural products with *Solanum elaeagnifolium* is prohibited in South Africa (Wassermann *et al*., 1988).

In 2006, *S. elaeagnifolium* was recommended for regulation in the EPPO region as an A2 pest.

Phytosanitary measures could include that plants for planting with growing medium attached originating from countries where the pest is present should be grown in a growing medium free from the pest or should come from a pest-free area or pest-free place of production for *S. elaeagnifolium*.

Soil/growing medium (with organic matter) as a commodity originating from countries where the pest is present should be collected in a pest-free place of production or pest-free area for *S. elaeagnifolium*.

Seeds of *Gossypium* spp., *Hordeum indicum, Medicago sativa, Nicotiana tabacum, Sesamum indicum, Sorghum bicolor, Triticum* spp., or *Zea mays* from countries where the pest occurs should be cleaned or should come from a pest-free area or pest-free place of production for *S. elaeagnifolium*.

Consignments of grain (*Hordeum* spp., *Sesamum indicum, Sorghum bicolor, Triticum* spp, *Zea mays*) from countries where the pest occurs should be cleaned, or should come from a pest-free area or pest-free place of production for *S. elaeagnifolium*.

Cleaning or disinfection of imported machinery or vehicles from countries where the pest occurs is recommended. Publicity to enhance public awareness on pest risks is a recommended measure as *S. elaeagnifolium* can be a contaminant on footwear. Use of clean containers and packaging material is also recommended.

References

Agence Méditerranéenne de l'Environnement (2006) Opération d'éradication de la morelle jaune sur la commune de Châteauneuf-les-Martigues, Languedoc-Roussillon (FR). http://www.ame-lr.org/plantes-envahissantes/solanum_cr.pdf [accessed on 7 November 2006]

Ameur A, Baye Y, Bouhache M & Taleb A (2007) Revue des moyens de lutte contre la morelle jaune (*Solanum elaeagnifolium* Cav.) au Maroc. *Bulletin OEPP/EPPO Bulletin* **37**, 137–144.

Baye Y, Ameur A, Bouhache M & Taleb A (2007) Stratégie de lutte chimique contre la morelle jaune (*Solanum elaeagnifolium* Cav.) au Maroc. *Bulletin OEPP/EPPO Bulletin* **37**, 145–152.

Baye Y & Bouhache M (2007) Etude de la compétition entre la morelle jaune (*Solanum elaeagnifolium* Cav.) et le maïs de printemps (*Zea mays* L.) *Bulletin OEPP/EPPO Bulletin* **37**, 129–131.

Bothma A (2002) Alleopathic potential of silverleaf nightshade (*Solanum elaeagnifolium* Cav.) MSc (Agric) Horticulture. University of Pretoria, Pretoria (ZA). http://upetd.up.ac.za/thesis/available/etd-10072005–121704 [accessed on 7 November 2006]

Boukhris-Bouhachem S, Hullé M, Rouzé-Jouan J, Glais L & Kerlan C (2007) *Solanum elaeagnifolium*, a potential source of *Potato virus Y* (PVY) propagation. *Bulletin OEPP/EPPO Bulletin* **37**, 125–131.

Boyd JW & Murray DS (1982) Growth and development of silverleaf nightshade (*Solanum elaeagnifolium*). *Weed Science* **30**, 238–243.

Burrows GE, Tyrl RJ & Edwards WC (1981) Toxic plants of Oklahoma – thornapples and nightshades. *Journal of the Oklahoma Veterinary and Medical Association* **23**, 106–109.

California Department for Food and Agriculture (2006) California (US). http://www.cdfa.ca.gov/phpps/ipc/weedinfo/solanum-carolinense.htm [accessed on 23 April 2007]

Chalghaf E, Aissa M, Mellassi H & Mekki M (2007) Maîtrise de la propagation de la morelle jaune (*Solanum elaeagnifolium* Cav.) dans le gouvernorat de Kairouan (Tunisie). *Bulletin OEPP/EPPO Bulletin* **37**, 132–136.

Cuthbertson EG, Leys AR & McMaster G (1976) Silverleaf nightshade – a potential threat to agriculture. *Agricultural Gazette of New South Wales* **87**, 11–13.

Davis CH, Smith TJ & Hawkins RS (1945) Eradication of the white horsenettle in southern Arizona. *Bulletin no. 195, 1–14 Agricultural Experiment Station*. University of Arizona, Tucson (US).

Dollahite JW & Allen TJ (1960) *Silverleaf Nightshade Poisoning in Livestock. Progress Report no. 2146*. Texas Agricultural Experiment Station, Vernon, Texas (US).

Eleftherohorinos IG, Bell CE & Kotoula-Syka E (1993) Silverleaf nightshade (*Solanum elaeagnifolium*) control with foliar herbicides. *Weed Technology* **7**, 808–811.

Gmira N, Douira A & Bouhacje M (1998) Ecological grouping of *Solanum elaeagnifolium*: a principal weed in the irrigated Tadla plain (central Morocco). *Weed Research* **38**, 87.

Goeden RD (1971) Insect ecology of silverleaf nightshade. *Weed Science* **19**, 45–51.

Gorrell RM, Bingham SW & Foy CL (1981) Control of horsenettle (*Solanum carolinense*) fleshy roots in pastures. *Weed Science* **29**, 586–589.

Hare JD (1990) Ecology and management of the Colorado potato beetle. *Annual Review of Entomology* **35**, 81–100.

Heap JW & Carter RJ (1999) The biology of Australian weeds. 35. *Solanum elaeagnifolium* Cav. *Plant Protection Quarterly* **14**, 2–12.

Heap J, Honan I & Smith E (1997) *Silverleaf Nightshade: A Technical Handbook for Animal and Plant Control Boards in South Australia*. Primary Industries South Australia, Animal and Plant. Control Commission, Naracoorte (AU).

Hoffmann JH, Moran VC & Impson FAC (1998) Promising results from the first biological control programme against a solanaceous weed (*Solanum elaeagnifolium*). *Agriculture, Ecosystems and Environment* **70**, 145–150.

Hsu TW & Tseng YH (2003) *Solanum elaeagnifolium* Cav. (Solanaceae): A noxious weed newly naturalized to Taiwan. *Endemic Species Research* **5**, pp. 49–51. http://wwwdb.tesri.gov.tw/protect/L2_show_detail.asp?L1_autoid=20&L2_autoid=75 [accessed on 9 November 2006]

Klein H (2001) South Africa and Morocco combine forces against 'the Devil's own weed'. *Plant Protection News* **58**, 10–11.

Maiti PC (1967) Rich sources of solasodine. *Current Science* **36**, 126.

McLain J, Castle S, Holmes G & Creamer R (1998) Physiochemical characterization and field assessment of *Lettuce Chlorosis Virus Plant Disease* **82**, 1248–1252.

Molnar VM & McKenzie DN (1976) *Progress Report on Silverleaf Nightshade Research*. Pamphlet no. 61. Keith Turnbull Research Institute, Victoria (AU).

Morton CV (1976) *A revision of the Argentine species of* Solanum. Academia Nacional de Ciencas, Cordoba (AR).

Northam FE & Orr CC (1982) Effects of a nematode on biomass and density of silverleaf nightshade. *Journal of Range Management* **35**, 536–537.

Olckers T, Hoffmann JH, Moran VC, Impson FAC & Hill MP (1999) The initiation of biological control programmes against *Solanum elaeagnifolium* Cavanilles and *S. sisymbriifolium* Lamarck (Solanaceae) in South Africa. *African Entomology Memoir, 1: Biological Control of Weeds in South Africa (1990–98)*, 55–63.

Olckers T & Zimmermann HG (1991) Biological control of silverleaf nightshade, *Solanum elaeagnifolium*, and bugweed, *Solanum mauritanum*, (Solanaeae) in South Africa. *Agriculture, Ecosystems and Environment* **37**, 137–155.

Parsons WT (1981) *Noxious Weeds of Victoria*. Inkata Press, Melbourne (AU).

Patrock RJ & Schuster DJ (1992) Feeding, oviposition and development of the pepper weevil, (*Anthonomus eugenii* Cano), on selected species of Solanaceae. *Tropical Pest Management* **38**, 65–69.

Richardson RG & McKenzie DN (1981) Regeneration of, and toxicity of 2,4-D, to root fragments of silver-leaf nightshade (*Solanum elaeagnifolium* Cav.). *Journal of the Australian Institute of Agricultural Science* **47**, 48–50.

Robinson AF, Orr CC & Heintz CE (1978) Distribution of *Nothanguina phyllobia* and its potential as a biological control agent of silverleaf nightshade. *Journal of Nematology* **10**, 361–366.

Roche C (1991) *Silverleaf Nightshade (Solanum Elaeagnifolium* Cav.*)* Pacific Northwest Extension Publication 365, Washington State University (US).

Rutherford PA (1978) Effect of time of immersion in running and still water on the germination of silver-leaf nightshade (*Solanum elaeagnifolium*). Proceedings of the first conference of the Council of Australian Weed Science Societies, pp. 372–378. Melbourne, Victoria (AU).

Sforza R & Jones WA (2007) Potential for classical biocontrol of silverleaf nightshade in the Mediterranean Basin. *Bulletin OEPP/EPPO Bulletin* **37**, 156–162.

Stoltsz CW (1994) *Vegetative regeneration of the weed* Solanum elaeagnifolium (*silverleaf nightshade*). MSc Thesis. University of Port Elizabeth, Port Elizabeth (ZA).

Stubblefield RE & Sosebee RE (1986) Herbicidal control of silverleaf nightshade. *Proceedings of the Western Society of Weed Science* **39**, 117–118.

Symon DE (1981) A revision of the genus *Solanum* in Australia. *Journal of the Adelaide Botanical Garden* **4**, 1–367.

Taleb A (2006) Etat actuel de nos connaissances sur les plantes envahissantes au Maroc. In *Invasive Plants in Mediterranean Type Regions of the World* (ed. Brunel S), pp. 99–107. Council of Europe Publishing, Strasbourg (FR).

Tanji A, Boulet C & Hammoumi M (1984) Contribution to the study of the biology of *Solanum elaeagnifolium* Cav. (Solanaceae), a weed of crops in the irrigated perimeter of the Tadla (Morocco). *Weed Research* **24**, 401–409.

USDA-NRCS (2005) The PLANTS Database, Version 3.5 *National Plant*. Data Center, Baton Rouge (US). http://plants.usda.gov [accessed in February 2006]

Viljoen BD & Wassermann VD (2004) Suppression of Silver-leaf bitter apple (*Solanum elaeagnifolium* Cav.) by cultivated pasture crops under dry-land conditions: a preliminary study. *South African Journal of Plant and Soil* **21**, 63–66.

Wapshere AJ (1988) Prospects for the biological control of silver-leaf nightshade, *Solanum elaeagnifolium*, in Australia. *Australian Journal of Agricultural Research* **39**, 187–197.

Washington State Noxious Weed Control Board (2006) *Silverleaf Nightshade* (Solanum elaeagnifolium *Cav.*). Olympia, Washington (US). http://www.nwcb.wa.gov/weed_info/Solanum_elaeagnifolium.html [accessed on 9 November 2006]

Wassermann VD, Zimmermann HG & Neser S (1988) *The Weed Silverleaf Bitter Apple ('Satansbos') (*Solanum elaeagnifolium *Cav.)* with special reference to its status in South Africa. Technical Communication no. 214. Department of Agriculture and Water Supply, Pretoria (ZA).

Yannitsaros A & Economidou E (1974) Studies on the adventive flora of Greece – I. General. Remarks on some recently introduced taxa. *Candollea* **29**, 111–119.

Zaki N, Eljadd EL, Oihabi A, Tanji A & Hilali S (1995) Effet de la combinaison de la lutte chimique et mécanique sur la Morelle jaune (*Solanum elaeagnifolium* Cav.) Deuxième congrès de l'AMPP, Rabat (MA).

Appendix

References for geographical distribution

Algeria

Fenni M & Sarri D (2005) Pers. comm.

Argentina

Holm LG, Pancho JV, Herberger JP & Plucknett DL (1979) *A Geographical Atlas of World Weeds*. John Wiley and Sons, New York (US).

Portal do gobierno do estado do Sao Paolo (2006) Herbário, Instituto Agronômico de Campinas (BR). http://www.iac.sp.gov.br/Herbario/Relatorios/ConsultaHerbario.asp?NumIac=22498 [accessed on February 2006]

Australia

Thorp JR & Wilson M (1998 onwards) *Weeds Australia*. http://www.weeds.org.au/noxious.htm [accessed in February 2006]

Australia's Virtual Herbarium (2001 onwards) http://www.rbg.vic.gov.au/cgi-bin/avhpublic/avh.cgi [accessed in April 2006].

Chile

Holm LG, Pancho JV, Herberger JP & Plucknett DL (1979) *A Geographical Atlas of World Weeds*. John Wiley and Sons, New York (US).

Croatia

Gazi Baskova V & Segulja N (1978) The appearance of dangerous weeds of the genus *Solanum* on the Kvarner Island of Plavnik. *Fragmenta Herbologica Jugoslavica* **6**, 55–59.

Milovic M (2001) A contribution to the knowledge of the neophytic flora of the County of Sibenik and Knin (Dalmatia, Croatia). *Natura Croatica* **10**, 277–292.

Pandza M & Stancic Z (1999) New localities of the species *Datura innoxia* Miller and *Solanum elaeagnifolium* Cav. (Solanaceae) in Croatia. *Natura Croatica* **8**, 117–124.

Pavletic Z, Devetak Z & Trinajstic I (1978) A new remarkable habitat of the neophyte *Solanum elaeagnifolium* Cav. in flora of the Croatian coast. *Fragmenta Herbologica Jugoslavica* **6**, 69–72.

Cyprus

Meikle RD (1977–1985) *Flora of Cyprus*, 2 Vol. Bentham-Moxon Trust Publishers, Kew (GB).

Denmark

Hans Peter Ravn (2006) Pers. comm.

North European and Baltic Network on Invasive Alien Species (NOBANIS) (2006) Alien species database. http://www.nobanis.org [accessed in February 2007]

Egypt

Boyd JW, Murray DS & Tyrl RJ (1984) Silverleaf nightshade, *Solanum elaeagnifolium*, origin, distribution and relation to man. *Economic Botany* **38**, 210–217; 41.

France

Agence Méditerranéenne de l'Environnement (2006) *Action* Solanum elaeagnifolium. http://www.ame-lr.org/plantes-envahissantes [accessed in February 2006]

EPPO Reporting Service (2006/020) Eradication of *Solanum elaeagnifolium* in Châteauneuf-les-Martigues (FR) *EPPO Reporting Service/Service d'Information OEPP*, no. 1. OEPP/EPPO, Paris (FR). http://archives.eppo.org/EPPOReporting/2006/Rse-0601.pdf [accessed on 9 November 2006]

Greece

Boyd JW, Murray DS & Tyrl RJ (1984) Silverleaf nightshade, *Solanum elaeagnifolium*, origin, distribution and relation to man. *Economic Botany* **38**, 210–217; 41.

Browicz K (1993) *Nicotiana glauca* and *Solanum elaeagnifolium* (Solanaceae) – two xenophytes from South America and the history of their spreading in the eastern Mediterranean. *Fragmenta Floristica et Geobotanica* (Supplement 2, 1), 299–305.

Davis PH (1965–1985) *Flora of Turkey and the east Aegean islands*. Vol. 1–9. Edinburgh University Press, Edinburgh (GB).

Eleftherohorinos IG, Bell CE & Kotoula-Syka E (1993) Silverleaf nightshade (*Solanum elaeagnifolium*) control with foliar herbicides. *Weed Technology* **7**, 808–811; 21.

Yannitsaros A & Economidou E (1974) Studies on the adventive flora of Greece – I. General remarks on some recently introduced taxa. *Candollea* **29**, 111–119.

Zahariadi C (1973) Quelques taxons rares ou nouvellement découverts de la flore de Grèce. *Annales Musei Goulandris* **1**, 165–183.

India

Babu VS, Muniyappa TV & Shivakumar HR (1995) Studies on biology and herbicidal control of silverleaf nightshade (*Solanum elaeagnifolium* Cav.). *World Weeds* **2**, 99–105.

Holm LG, Pancho JV, Herberger JP & Plucknett DL (1979) *A Geographical Atlas of World Weeds*. John Wiley and Sons, New York (US).

Israel

Database of the Jerusalem Botanical Garden (2005) http://www.botanic.co.il [accessed in February 2006]

Italy

Boyd JW, Murray DS & Tyrl RJ (1984) Silverleaf nightshade, *Solanum elaeagnifolium*, origin, distribution and relation to man. *Economic Botany* **38**, 210–217; 41.

di Martino A (1956) [One *Solanum elaeagnifolium* Cav. var. *Leprosum* site in Sicilia.] *Lav. Reale Ist. Bot. (Palermo)* **15**, 114–120 (in Italian).

Mexico

Holm LG, Pancho JV, Herberger JP & Plucknett DL (1979) *A Geographical Atlas of World Weeds*. John Wiley and Sons, New York (US).

Morocco

Qorchi M & Taleb A (1997) Situation actuelle de l'infestation par la Morelle jaune au Maroc. *Journée nationale sur la morelle jaune : ampleur du problème et stratégies de lutte*. Afourer, 5–8.

Pakistan

Department of Botany, University of Karachi, Pakistan and National Herbarium (Stewart Collection) (1979) Flora of Pakistan, n°100. Pakistan Agricultural Research Council, Islamabad (PK).

Puerto Rico

USDA-Plants Database (2006) Plants Profile: *Solanum elaeagnifolium* Cav. *Map of the USA*. http://plants.usda.gov/java/profile?symbol=SOEL [accessed in February 2006]

Serbia

Krstic L, Pal B & Anackov G (2000) The distribution of *Solanum* L. species in Vojvodina. *Pesticidi* **15**, 271–286.

South Africa

Southern African Agricultural Geo-referenced Information System website (2006) *Distribution map*. http://www.agis.agric.za/agisweb/agis.html [accessed in February 2007]

Spain

Aparicio A (2003) [Naturalizad taxa in the Iberian Peninsula present in Western Andalucia.] *Acta Botanica Malacitana* **28**, 253 (in Spanish).

Carretero JL (1989) The alien weed flora of the Valencian community (Spain). *Proceedings of the 4th EWRS symposium on weed problems in Mediterranean climates*. Vol. 2. Problems of weed control in fruit, horticultural crops and rice, 113–124.

OEPP/EPPO (2005) Two naturalized taxa in the Iberian Peninsula present in west Andalucia (Spain) (2005/128). *EPPO Reporting Service/Service d'Information OEPP*, no. 9. OEPP/EPPO, Paris (FR). http://archives.eppo.org/EPPOReporting/2005/Rse-0509.pdf [accessed on 9 November 2006]

OEPP/EPPO (2005) Presence of *Solanum elaeagnifolium* in the North of Spain (2005/129) *EPPO Reporting Service/Service d'Information OEPP*, no. 9. OEPP/EPPO, Paris (FR). http://archives.eppo.org/EPPOReporting/2005/Rse-0509.pdf [accessed on 9 November 2006]

Menéndez J, Bastida F, Fernández-Quintanilla C, Gonzáles JL, Recasens J, Royuela M, Verdu A & Zaragoza C (2005) [Weeds in the Iberian Peninsula and the Maghreb: common solutions to common problems.] *X Congresso de la Sociedad Española de Malherbologia*. Universidad de Huelva, Junta de Andalucía (in Spanish).

Syria

Al Mouemar A (2006) La Morelle jaune (S*olanum elaeagnifolium* Cav.), une espèce envahissante des cultures cotonnières du Nord de la Syrie. In *Invasive plants in Mediterranean Type Regions of the World* (ed. Brunel S). Council of Europe Publishing, Strasbourg (FR).

Tunisia

Chalghaf E (2007) Maîtrise de la propagation de la morelle jaune (*Solanum elaeagnifolium* Cav.) dans le gouvernorat de Kairouan (Tunisie). *Bulletin OEPP/EPPO Bulletin* **37**, 132–136.

Mekki M (2006) Potential threat of *Solanum elaeagnifolium* Cav. to Tunisian fields. In *Invasive plants in Mediterranean Type Regions of the World* (ed. Brunel S) . Council of Europe Publishing, Strasbourg (FR).

Zimbabwe

Holm LG, Pancho JV, Herberger JP & Plucknett DL (1979) *A Geographical Atlas of World Weeds*. John Wiley and Sons, New York (US).

USA

USDA-Plants Database (2006) *Map of the USA*. http://plants.usda.gov/java/profile?symbol=SOEL [accessed in February 2006]. Details are provided for California, Utah, Kansas, Arkansas, Illinois, Tennessee, Georgia, North Carolina, South Carolina and Florida.

Hawaiian Ecosystems at Risk Project (2004) *Known distribution of S. elaeagnifolium in Hawaii*. http://www.hear.org/maps/plants/hawaii/solanum_elaeagnifolium.htm [accessed in February 2006]