Silverleaf nightshade: progress and prospects for management of a new Australian WoNS

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Summary Silverleaf nightshade (*Solanum elaeagnifolium* Cav.) is recognised as one of the world's worst agricultural weeds, and has recently been included as one of 12 new Australian Weeds of National Significance (WoNS). It currently infests over one million hectares of productive farmland in Australia, is still spreading, and has the potential to infest almost all of the farmlands in the cereal growing regions of South Australia, New South Wales, Victoria and Western Australia. It is a competitive, tenacious, drought-tolerant perennial weed that has a very extensive and resilient root system. Herbicides that are suitable for use on crop production land give only short to medium-term control of shoots and seed set. Cultivation, mowing and burning are ineffective, and competitive crops and pastures give only limited control.

Once established, there are no practical methods available to destroy large core infestations. A renewed research and extension effort is needed to address this worsening problem. The most promising course of action appears to be a detailed feasibility study of the very successful biological control agent, *Leptinotarsa texana* Schaeffer, released in 1992 in South Africa.

Keywords Silverleaf nightshade, Weeds of National Significance, agricultural weed, perennial weed, biological control.

INTRODUCTION

Silverleaf nightshade is a deep-rooted perennial plant and one of Australia's worst agricultural weeds. It is thought to be a native of central America, and was recently listed in Australia as a Weed of National Significance (WoNS). It is a major weed in many regions around the world and is adapted to a wide range of disturbed agricultural habitats and soil types. In Australia it grows in an area corresponding to the wheat/sheep belt. It competes with crops and pastures and, once established in large infestations, is extremely difficult to kill. Silverleaf nightshade has spread widely since it was first found in northern New South Wales in 1901. It is most damaging in South Australia, Victoria and New South Wales, and also occurs in Western Australia and Queensland (Stanton *et al.* 2009). The largest infestations are in cropping and grazing land, with smaller infestations being found in irrigated pastures, orchards and vineyards, roadsides, channel banks and stockyards (McKenzie 1980). Seeds can be dispersed by contaminated animal dung, cultivation, infested hay and seed, flowing water, wind-blown dry stems, birds, machinery and vehicles (Stanton *et al.* 2009).

CURRENT SITUATION IN AUSTRALIA

Site inspections and personal interviews were conducted throughout 2012 and 2013 to provide a comprehensive evaluation of the current situation in Australia, and to identify priorities for future research and management.

Australian infestations Silverleaf nightshade spread throughout the Australian cereal/sheep belt is exemplified by spread in South Australia. In 1978, South Australia had an estimated 16,000 ha infested (J. Dickenson, pers. comm.). By 1990 it was at least 40,000 ha (South Australia Animal and Plant Control Commission, unpublished), and recent estimates suggest that it infests over 600,000 ha, and is still spreading (G. Roberts and I. Honan, pers. comm.). The area currently infested in Australia is believed to be greater than 1.1 million ha, and annual agricultural productivity losses are estimated at $70 million (Heap, unpublished). There is still a serious risk that very large areas of clean and productive arable agricultural land will continue to be infested in South Australia, Victoria and Western Australia.

The largest infestations are in South Australia, New South Wales and Victoria. In South Australia it is considered to be predominantly a weed of crops. In New South Wales and Victoria it is recognized as a serious weed of both crops and pastures. It is also a troublesome weed in horticultural crops (e.g. grape vines) grown on infested ex-cropping land. Silverleaf nightshade is not a problem in Tasmania. In Queensland there are only a few recorded infestations in the south of the state, and there appears to be little recognition or concern about it being a problem.

In Western Australia silverleaf nightshade is not yet widespread, but there is potential for it to spread throughout the wheat belt. It is currently a severe problem on five or six properties, and occurs as scattered infestations on another 50 to 70 properties (M. Clark

and P. Jolly, pers. comm.). The Western Australian wheat belt appears to be well suited for growth of established perennial silverleaf nightshade plants, but spread has probably been significantly slowed by the limiting effect on seedling recruitment from the strong Mediterranean climate, with little summer rain in most seasons. It is very likely that seeds are frequently spread from farm to farm in dung from contaminated sheep. In most seasons seedlings that might emerge after a summer thunder storm are probably killed by moisture stress induced by succeeding hot summer days. Spread in Western Australia probably relies on a specific series of summer rainfall events spaced so as to sustain seedling growth into perennial shoots. This pattern is rare in the Western Australian wheat belt, but may have occurred during the 2011–2012 summer.

Spread Silverleaf nightshade spreads primarily by seed transported by livestock (sheep in particular), and also by root and stem fragments (Stanton *et al.* 2009). In New South Wales spread by dragged root and shoot fragments during cultivation or sowing appears to be as important as spread by seed (H. Wu, pers. comm.). In South Australia and Western Australia observations and anecdotal evidence suggests that sheep are by far the most important vector. Heap and Honan (1993) reported that sheep in South Australia ate both fresh green berries and mature berries during the summer/autumn period, and that viable seed was passed in dung up to 31 days after ingestion. In South Australia there is evidence that clonal growth is the predominant mode of vegetative spread. Distinctive white-flowered clonal colonies sometimes grow amongst purple-flowered colonies. If establishment of new plants from dragged fragments were common, one would expect to observe white-flowered colonies elongated and extended in the direction of cultivation or sowing. This has not yet been observed by the author.

During interviews, convincing anecdotal evidence was also recounted for spread by berries falling from tumbling wind-blown dry stems, contaminated hay, and flood waters. There were also reports of mature berries found in harvested pea grain (I. Honan, pers. comm.).

Management in agriculture Silverleaf nightshade is primarily managed using herbicides. Cultivation, mowing, grazing and burning have little effect on the perennial root system (Stanton *et al.* 2009). Competition from deep-rooted perennials can reduce shoot vigour, and there is evidence that some *Eucalyptus* spp. suppress growth through allelopathy (R. Thompson, pers. comm.).

Economic impacts and perceived threats from silverleaf nightshade vary around Australia, and this is reflected by a wide array of management approaches. Three broad categories of farmers were encountered: those that do not have any silverleaf nightshade; those that have isolated or scattered infestations; and those that have extensive perennial infestations.

Farm hygiene is the first and most effective line of defence. Clean properties can be protected by vigilance when obtaining sheep or hay from infested areas. Quarantining of new livestock in a small area, as suggested by Heap and Honan (1993), is observed by some, but is by no means universal. However, it is encouraging that on Eyre Peninsula (South Australia) rates of spread by sheep have apparently been slowed by public awareness created by publicity of research results (I. Honan, pers. comm.).

Treatment of isolated outlier infestations with herbicides can be effective. A number of growers related that they had a known and chronic seed incursion source (e.g. neighbour's fence, or contaminated sheep from an associated property) but, with regular inspections, effective herbicide treatments (predominantly glyphosate or picloram) and careful vigilance, paddocks had remained clean for several decades. The cost of these treatments and crop damage caused by soil residues of some herbicides precludes spot-treatments from large infestations.

Extensive infestations are often an intransigent problem. Some growers report good progress following successive years of herbicide application, but many report that they are making little long-term impact on the perennial root system. Herbicides are typically applied to silverleaf nightshade during summer, usually concurrently targeting other summer weeds. They are applied to reduce flowering, seed-set, competition for water and nutrients, and physical interference with seeding machinery. This can typically increase subsequent crop yields by 20 to 40%. Glyphosate is the most commonly used herbicide, usually combined with other herbicides to suit the spectrum of other weeds present. The herbicides for these applications typically cost \$15 to \$20 ha^{-1}, and several applications may be required – one to control seed-set, and a later treatment to suppress the root system (H. Wu, pers. comm.). Fluroxypyr is increasingly used instead of 2,4-D amine to kill shoots and reduce seed-set, however there is little evidence that either of these herbicides cause significant damage to perennial roots at the rates used.

RESEARCH AND EXTENSION IN AUSTRALIA

Past and current activities Research and extension efforts made in the 1970s and 1980s led to reduced

spread, eradication of some infestations, and improved understanding of the biology and management of extensive infestations. Since then research has been sporadic and ad-hoc, and most control has been undertaken by regional NRM/CMAs.

Since 2006 there have been several research and extension projects. Most were funded by Meat and Livestock Australia, and were based at the Wagga Wagga Agricultural Institute. They included field experiments and studies on biology, genetics, and morphology (H. Wu, pers. comm.). A new research and extension project (Biosecurity South Australia; 2013 to 2016), funded by the South Australia Grains Industry Trust, is exploring biology and control of silverleaf nightshade.

Weed of National Significance Silverleaf nightshade was inducted as a Weed of National Significance (WoNS) in 2012, conferring greater impetus for increased RD&E activity. It was selected due to its invasiveness, competitiveness, fecundity, accessibility, invasive pathways, and a high level of expected cooperation from landholders. A Weed Management Coordinator for silverleaf nightshade (funded by DAFF) was appointed and hosted by Biosecurity South Australia in 2012, joining an existing network of Coordinators for WoNS species throughout Australia.

A National Strategic Plan for silverleaf nightshade was prepared and published under the auspices of the Australian Weeds Committee, addressing three main goals: New infestations are prevented from establishing; Extensive infestations are under strategic management; and Greater capability and commitment to manage silverleaf nightshade (Australian Weeds Committee, 2012). The national coordination role facilitated additional activity against silverleaf nightshade, but funding for WoNS Coordinators was discontinued after June 2013. Silverleaf nightshade remains a WoNS and stakeholders are encouraged to contribute towards achieving the goals of the National Strategic Plan.

FUTURE MANAGEMENT PROSPECTS

Silverleaf nightshade will almost certainly continue to spread in Australia, and the magnitude of recurring annual losses will compound and grow inexorably. Three areas are particularly at risk from further invasion: The extensive cereal cropping belt of south-west Western Australia; Large areas of un-infested arable land within the 'current distribution' range; and Horticultural and irrigated crops.

There is a clear need for better management strategies, particularly for extensive infestations. This need can best be met by new research, and to some extent, increased extension of existing knowledge. A worldwide search for a new 'silver bullet' herbicide over the last 50 years has so far failed. Current management strategies rely heavily on herbicides, and it is likely that research will only be able deliver incremental improvements in the efficacy of existing available chemistry.

In the absence of a new and spectacularly efficacious herbicide, there seems little other hope for reducing extensive infestations than an effective biological control program. Biological control represents one of the best, and last, hopes for sustainably controlling silverleaf nightshade in Australia.

Biological control in Australia? During the 1970s Australia recognised the need for direct participation in biological control investigations (Moore *et al.* 1975). Kwong and Sagliocco (2012) recently reviewed the feasibility and cost-benefit analyses for biological control of SLN in Australia, and confirmed that further efforts are warranted. Two recent developments have re-awakened interest and hope in Australia. The first was the success of a biological control agent (*Leptinotarsa texana*) in South Africa (Olckers *et al.* 1999). The second was recognition of the potential for exploration of central regions of Argentina and Chile, with climatic conditions more closely matched to those in southern Australia (Kwong *et al.* 2008).

***Leptinotarsa texana*: a South African success** A defoliating beetle, *L. texana*, has spectacularly reduced the impact of silverleaf nightshade since its release in South Africa in 1992 (Olckers *et al.* 1999). Dr Helmuth Zimmermann, a South African biological control expert, recently visited Adelaide and gave a presentation on the outstanding success of the project. *L. texana* defoliates silverleaf nightshade in massive waves, and has reduced silverleaf nightshade to minor weed status. It establishes readily and eats both leaves and bark, severely weakening and eventually killing perennial plants. Initial fears of damage to egg plant crops have not eventuated as a problem in the field. The first-hand South African account sparked enormous enthusiasm and hope amongst Australian scientists with an interest in silverleaf nightshade. The successful South African project is summarised by Kwong and Sagliocco (2012).

DISCUSSION

The challenge for silverleaf nightshade management is to increase levels of capacity, awareness, and willingness to manage this weed before it spreads to its full potential geographic range and severely reduces Australia's important agricultural production base.

Many farmers in New South Wales, South Australia, and Victoria are fighting a losing battle against this invasive perennial. Cultivation, grazing and fire are ineffective, and broad-acre herbicides give only temporary suppression.

The best and only real hope for managing this weed effectively is biological control. Biological control projects started from scratch are often long and complex. The successful *L. texana* project in South Africa offers Australia a rare opportunity to significantly reduce the effort normally required. Biosecurity South Australia (PIRSA) has begun negotiations aimed at securing local funding for a feasibility study on the potential for *L. texana* in Australia. This project will aim to investigate the South African project and experience, and assess its potential for similar success in Australia. If the feasibility study outcomes are positive, further national agricultural industry research funding will be sought.

ACKNOWLEDGMENTS

Funding support from Biosecurity South Australia (PIRSA), the South Australian Grains Industry Trust, and DAFF is gratefully acknowledged. Thanks also to Biosecurity South Australia staff, former WoNS Weed Management Coordinators, regional NRM and CMA officers, and collaborating farmers and consultants.

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