Silverleaf nightshade research update – summer 2009

Background

Silverleaf nightshade (SLN) arrived in Australia on multiple occasions in the early 1900s as a contaminant of grain and fodder. It remained as a sleeper weed until the 1960s when it spread rapid across south eastern Australia, including much of NSW (Figure 1). It is currently rated as one of the worst weeds in New South Wales.

SLN is spread through cultivation, animals and seed production and competes directly with summer growing crops and pastures, and reduce production of winter crops such as cereals.

Improved management options will reduce control costs (which are currently very expensive) and lessen the direct impacts of the weed on agricultural production in the short-term. In the long-term reducing the spread of SLN will reduce future weed costs.

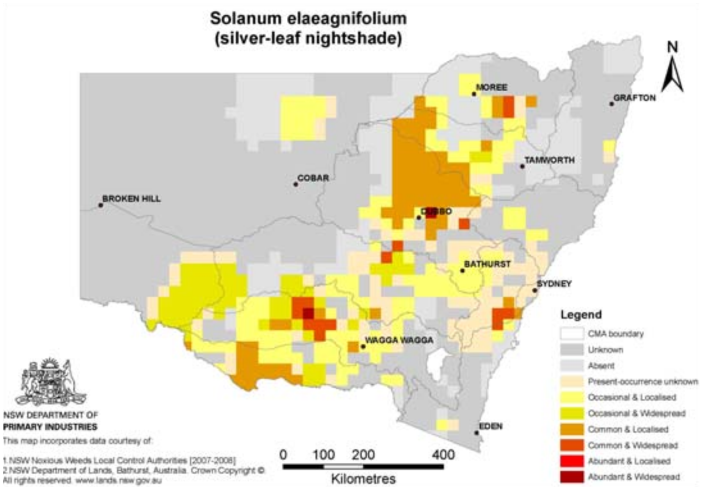

Figure 1. Current distribution of silverleaf nightshade in NSW. **(**courtesy Sean Brindle, NSW DPI**)**

SLN Impact

SLN is a deep-rooted, summer-growing perennial weeds of the Solanaceae family that grow in the cropping/pasture zone of southern Australia. Once established it is very difficult to control.

Case studies of farmers in southern NSW indicate that SLN control is estimated to cost farmers $10/ha or more in control costs.

In addition, SLN can reduce stock carrying capacity by 20-50% and crop production losses are estimated at 20%. The presence of SLN is also estimated to decrease land values by 20-25%.

Key messages:

Be alert to new occurrences of SLN as new infestations are easier to control than established infestations

Maintain biomass during winter/spring and into summer to provide competition to emerging SLN stems and seedlings

Prevent seed set to reduce the seedbank by use of herbicides or mechanical control

Prevent seed movement to clean areas by cleaning equipment and managing livestock exposed to mature berries

Control rootstock by using herbicides at the end of summer when there is increased translocation towards the roots

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an alliance between Charles Sturt University & NSW Department of Primary Industries

Project objectives

To discover, develop and communicate innovative technologies for the economic control and management of silverleaf nightshade through a primary focus on the following control opportunities:

- increasing herbicide efficacy with better timing in relation to weed phenology, spray application timing, environmental factors and new application technology, based on a better understanding of uptake and translocation
- competitive perennial pastures (legume and non-legume) and mulch crops (summer and winter)
- allelochemicals for control of SLN will be identified and evaluated in glasshouse and field trials and selectivity determined
- increasing the understanding of the basic biology and ecology of SLN

Herbicide choice

The *NSW DPI Noxious and Environmental Weed Control Handbook, 3rd edition* lists several active ingredients as currently registered for control of SLN; namely fluroxypyr, glyphosate and 2,4-D amine + picloram.

Starting in the 2006/07 summer, a range of alternative active ingredients have been evaluated as part of the current research project. Herbicides from Group C (eg atrazine) and Group L (eg paraquat/diquat) have proved largely ineffective to date for long term control of SLN. Paraquat/diquat provided short term defoliation and may be a useful alternative for controlling flowering during the season.

Amitrole (Group Q), when used at 4L/ha and applied at flowering/early berry set, has not provided significant control, either within season or into the next season.

A range of Group I herbicides containing one or more of the active ingredients such as aminopyralid, fluroxypyr, picloram or triclopyr provided 80-90% control of stems during the season (Figure 2). Stem numbers were reduced by 40-70% at the start of the next season compared to untreated controls.

Glyphosate (Group M) has not been as effective with only 10-20% control observed within season, due either to poor efficacy or SLN stems regenerating after the herbicide was applied. There was a 30-50% reduction in stems numbers at the start of the next season compared to untreated controls (Figure 3).

One field site is adjacent to an unsealed road resulting in the SLN plants being exposed to high levels of dust. Increased dust levels will decrease glyphosate efficacy as the glyphosate molecules are bound to the dust particles before they can be absorbed by the plants.

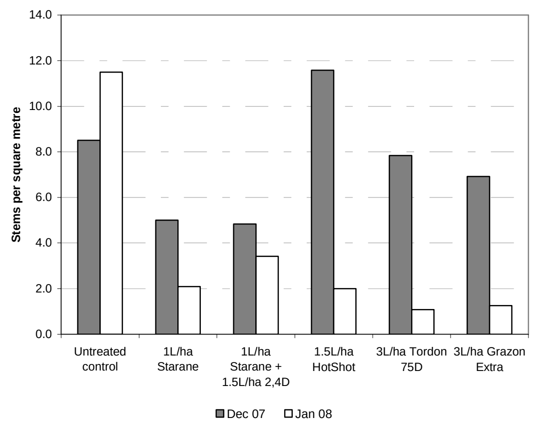


Figure 2. Efficacy of Group I herbicides for SLN control within season (averaged over two sites).

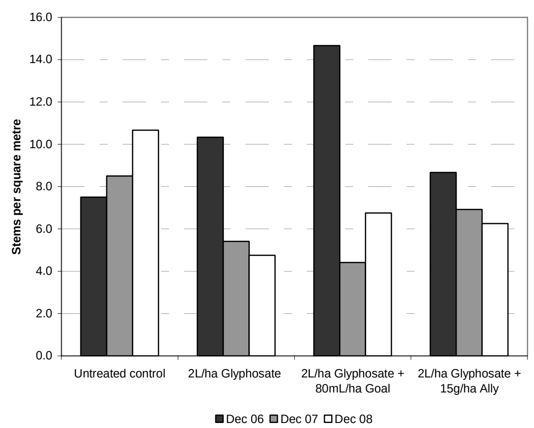


Figure 3. Efficacy of Group M herbicides for SLN control across seasons (averaged over two sites).

Herbicide application timing

The efficacy of a herbicide can be greatly influenced by the stage of growth of the target weed.

Current recommendations for herbicide control of SLN are to spray at the early berry set growth stage. This is important to help stop seed set, but might not be the best option to controlling SLN roots.

Research conducted at Adelaide University suggests that there is limited translocation to the root system while SLN is producing berries. There is increased translocation to the roots after berries have matured, suggesting that a spray application late in the season will result in more herbicide being transported to the roots.

This approach was included in research trials last summer. 225g a.i./ha picloram + 900g a.i./ha 2,4-D amine was applied in December 2007 during flowering/early berry set, and a second application of the same treatment was made to one set of plots at the start of April before the SLN started to naturally senesce.

Where the late season application was used, SLN emergence and growth was greatly reduced in the following December (Figure 4). This suggests a late season application is more effective at controlling SLN roots. Research will be repeated this summer to verify these results.

Single herbicide application in December 2007. (photo: December 2008)

Two herbicide applications, December 2007 and April 2008. (photo: December 2008)

Figure 4. Effect of application timing on SLN emergence the following season.

Role of adjuvants

Spraying conditions during summer are typically less than ideal and using adjuvants can often improve herbicide efficacy.

SLN plants were treated at several growth stages with fluroxypyr applied with 0.5L/ha Hasten (vegetable oil), 1L/ha Uptake (petroleum oil) or 19g a.i./ha oxyfluorfen (PPO inhibitor herbicide). The low rate of oxyfluorfen was used as a tank mix partner as this technique has been reported to assist with control of weeds such as annual ryegrass by modifying the leaf surface.

When treatments were applied at flowering, SLN plants did not reshoot when either of the crop oil adjuvants had been used. In contrast, when fluroxypyr was applied alone or with oxyfluorfen, 20-40% of treated plants reshot after treatment application.

Effect of herbicides on seed viability

SLN can be spread by either root fragments or by seed. Herbicides can be used to "spraytop" weeds to prevent viable seed being produced. Little is known about how effective this technique is for SLN. The long flowering season means there can be new (green, striped) and ripe (yellow) berries present during summer when sprays are normally applied.

SLN plants in the field were treated with 810g a.i./ha glyphosate + 250g a.i./ha dicamba in February. Individual berries were tagged and stage of maturity at spraying recorded. Berries were collected in March from sprayed and unsprayed plants and seed counted and tested for viability.

Seed viability for individual berries in all treatments was highly variable, suggesting berry colour alone may not be an simple indicator of seed maturity. Average viability for treatments indicates that spraytopping green berries may be more effective than spraytopping ripe berries (Table 1).

The variation in seed numbers between green and yellow berries may be a result of the time of year. Berries produced later in the season may be smaller and contain fewer seeds, suggesting that controlling early flowering and early berries is important to reduce the number of seeds being set.

Table 1. Effect of herbicides on SLN seed production and viability in relation to berry stage of maturity.

Treatment	Berry	Seed	
	Diam (mm)	Count	Viability
Green berries			
Control	10.3	30.2	70%
Sprayed	11.2	24.2	47%
Yellow berries			
Control	12.3	60.6	40%
Sprayed	12.5	64.2	29%

Competition from pastures and crops

Competition for resources (eg., water, nutrients) can be used as part of an IWM strategy to manage weeds. This competition can be direct through use of summer active species or indirect by using winter/spring active species to deplete the resources available at the start of summer when SLN emerges.

Glasshouse experiments indicate that a 2t/ha phalaris pasture can reduce SLN vigour by as much as 65%. In comparison, a 4t/ha lucerne pasture can reduce SLN vigour by more than 90%, and also significantly reduce stem numbers (Table 2).

Winter cereals can reduce early SLN emergence (Table 3). This could be a result of depleting the soil moisture available to SLN, or may also be from shading of the soil surface decreasing soil temperature.

This helps manage silverleaf nightshade by shortening the time in which it is active. Importantly, it means there will be more uniform emergence and growth of silverleaf nightshade, so that summer herbicide applications can be more targeted and applied to a higher percentage of the silverleaf nightshade population in a single operation.

Table 2. Effect of pasture competition on SLN under glasshouse conditions.

Treatment	Pasture (t/ha)	SLN stems	SLN Height (mm)
Control	-	2.0	283
Lucerne	4.1	0.3	17
Phalaris	2.1	2.0	100

Table 3. Influence of competition on SLN emergence in November.

Treatment	Biomass (t/ha)	SLN (stems/m^2)
Control	-	4.6
Ryegrass	0.3	1.2
Wheat	1.6	0.7
Saia oats	1.4	0.2
Cereal rye	2.0	0.2

Natural Herbicides

Allelopathy can be described as chemical warfare between plants, where a plant produces a compound that inhibits the growth of another plant species. This concept has been used to produce at least one natural herbicide; *Callisto™* is a commercial formulation of bottlebrush compounds which can be used for the control of a range of broadleaf weeds.

Anecdotal evidence suggests that some eucalypts suppress SLN. Four Western Australian species (*E. salubris*, *E. spathulata, E. brockwayi* and *E. dundasii*) are currently being investigated.

Field trials near Ungarie on 1-4 year old trees indicates that SLN stem numbers within 0.5m of the eucalypt decrease as the eucalypt height increases (Figure 5). However it has not been established experimentally the relative importance of allelopathy and competition for resources in the suppression of SLN.

Aqueous extracts were prepared from ground leaves of these four species, as well as *E. melliodora* and capeweed (*Arctotheca calendula*) as controls. SLN seed germination assays conducted in the laboratory indicated a significant reduction in seed germination (Figure 6). However, foliar sprays and application of powder to seedlings in the glasshouse has been less effective to date. Current research is focused on isolating essential oils from these eucalypts, as it is suspected these oils may play a role in suppressing silverleaf nightshade.

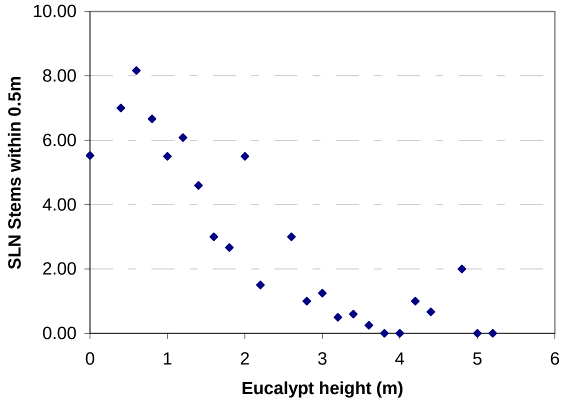


Figure 5. Influence of eucalypt height on SLN stem numbers (averaged across four eucalypt species).

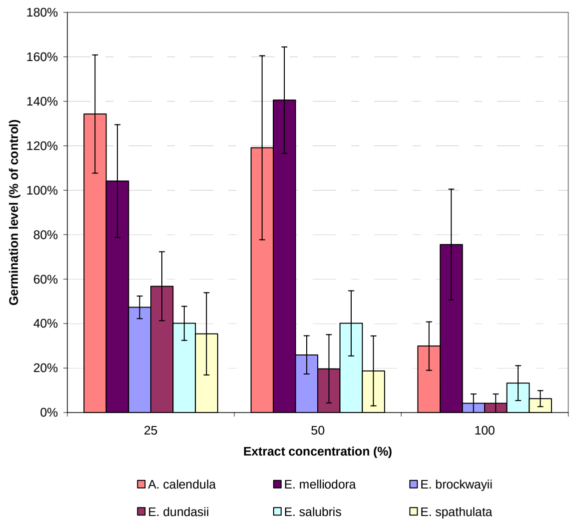


Figure 6. Influence of aqueous plant extracts on SLN germination.

Biocontrol

Classical biocontrol agents have been investigated previously by CSIRO and others. The most promising agent was not host specific and therefore was not suitable for release as a biocontrol agent.

In Florida, a tobacco mild green mosaic tobamovirus (TMGMV) has been identified as a biocontrol agent that provides 80-85% control of tropical soda apple (*S. viarum*).

S. viarum is closely related to SLN. Evaluation of the TMGMV on SLN seedlings has shown that SLN seedlings act as hosts for the virus, but do not show any symptoms. This pathogen would not be useful as a biocontrol agent for SLN.

Other potential agents will be evaluated for SLN biocontrol during the course of this project as opportunities are identified.

Silverleaf nightshade biology

Rootbank

SLN can be spread by either root fragments or by seed. Roots can be fragmented by cultivation, with the potential for some of these fragments to remain on the implement and be moved to a new area currently free of SLN.

SLN has an extensive root system, with potential to extend 2m or more both downward and sideways. Root fragments 10cm in length were collected from SLN plants in the field, cut into various lengths and buried at three depths in pots in the glasshouse. Fragments as short as 1cm are capable of producing a new stem Figure 7). All parts of this portion of the SLN root were equally viable.

Longer root fragments are capable of producing new stems from any depth. Shorter SLN root fragments are more successful at producing new stems when buried at 5cm depth. Shallower depths may be more prone to changes in temperature and moisture availability which may affect he viability of the root fragment. Short root fragments may not always have sufficient resources to get a new stem to the soil surface when buried deeper.

Cultivation will potentially increase SLN population size if nothing is done to control subsequent stem emergence.

Small root fragments are capable of forming new plants, therefore good farm hygiene practices need to be used to prevent spread of SLN.

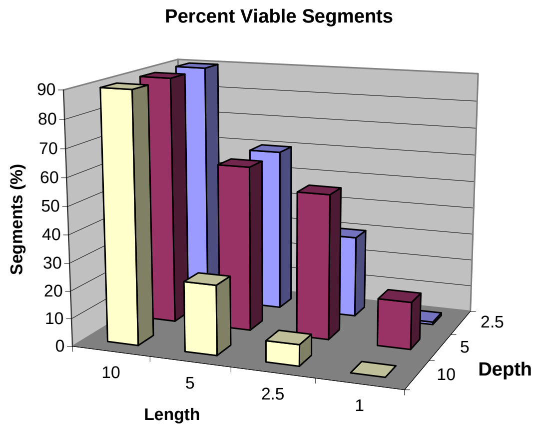


Figure 7. Effect of fragment size and burial depth on SLN root fragment viability.

Seedbank

The persistence of viable seed in the soil seedbank will determine how long you need to manage an area where SLN has occurred or does occur.

The mucous coating on the seeds reduces initial seed germination, and seeds need to be exposed to moisture to break down the mucous coating to stimulate germination.

If berries are buried intact, they provide protection for the seed for up to 12 months, prolonging the time the seed will persist in the soil seedbank (Figure 8). Berries on the soil surface or still on stems do not break down readily, allowing seed to persist for longer.

Initial results indicate SLN seed can persist for ten years or more. Controlling seed set will save years of monitoring for new germinations of SLN.

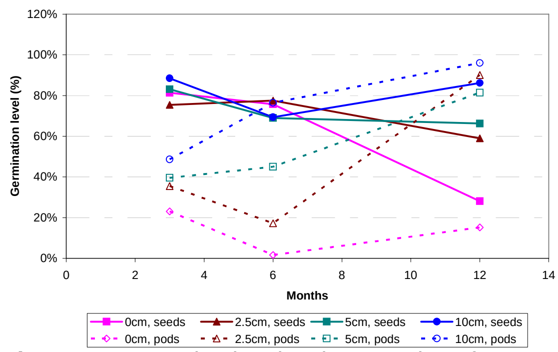


Figure 8. Germination levels over time for SLN seed buried bare or in berries.

Physiology

Ever wondered why the leaves of some plants look a bit silvery? In the case of Silverleaf nightshade, it is caused by a coating of trichomes or hairs-like growths composed of 8-16 lateral rays surrounding a central perpendicular ray Figure 9). These trichomes are more dense on the lower leaf surface, hence the whiter appearance when you turn the leaf over.

Herbicides are the major weapon used to manage this weed, but few land managers are able to successfully eradicate the weed once a population has become established.

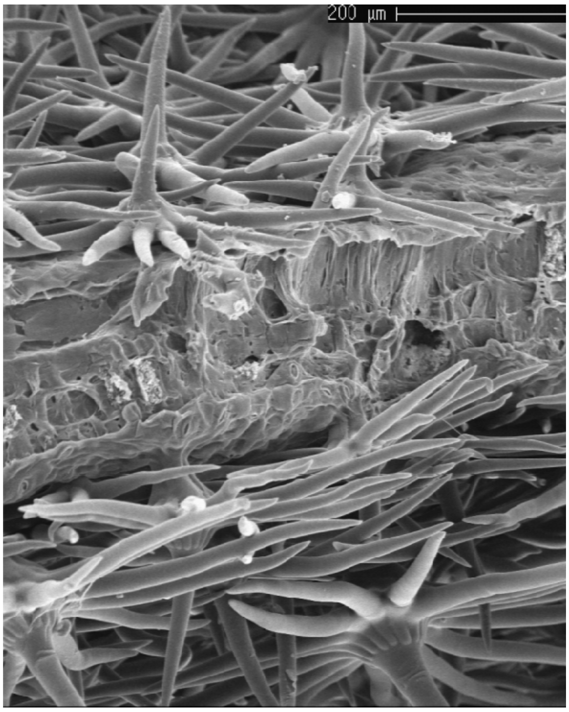
Trichomes composed of dead cells would create a barrier lowering herbicide uptake, however if these cells are alive and connected well into the leaf structure they may assist with herbicide uptake.

Unlike most trichomes, those on silverleaf nightshade have root-like structures that penetrate into the centre of the leaf.

The trichomes appear to have a cuticle and several layers of cells in their structure. Their role with in herbicide uptake is being investigated.

The findings of this research will potentially help develop herbicide application techniques to maximise herbicide uptake.

(a)



(b) Photo: Roger Heady

(c) Photo: Geoff Burrows

Figure 9. Images of SLN leaf structure showing (a) whole SLN leaf; (b) electron microscope image of a SLN leaf cut transversely; and (c) confocal microscope image of the root-like structure of a trichome.

SLN Management Plan

SLN is a persistent weed than can not be eradicated with a single operation. A control program needs to use as many approaches as possible.

From current research knowledge, a number of techniques could be used throughout the year that may assist with SLN control.

The techniques that are applicable will vary with every situation and will also depend on the size and density of the SLN infestation.

This list of options may not be exhaustive. Your feedback on other techniques that help control SLN would be appreciated.

Silverleaf Nightshade Management Options

	Purpose	Options
Spring	Provide competition to emerging SLN stems and seedlings	• Maintain ground cover in areas where SLN occurs using crops, annual pastures, perennial pastures or mulches
	Control SLN seedlings	• Spot spraying • Boom spraying • Chipping
	Management planning	• Monitor your land for new patches of SLN
Summer	Prevent viable seed set	• Spot spraying at flowering/berry set • Boom spraying at flowering/berry set • Slashing • Chipping • Hand weeding
	Prevent seed spread	• Do not graze once berries have formed • Do not make hay or silage from pastures once berries have formed
	Provide competition	• Summer active crop or pasture retain standing biomass for as long as possible
	Control SLN root stock	• Use residual herbicides as directed • A targeted late summer application of a Group I herbicide may assist with root control. Be aware of plant back periods if you use this technique • Dig out new, isolated plants before they become established
Autumn	Management planning	• Monitor your land and note where SLN is/was present for attention next season
	Reduce the soil seedbank	• Minimise cultivation to reduce the number of intact berries being buried • Remove and destroy as many berries as possible
Winter	Reduce SLN root spread	• Minimise cultivation in SLN areas • Clean down implements to minimise movement of root stock
	Competition	• Plan future land use to maximise potential competition to SLN during the next season(s)