Regeneration of silverleaf nightshade root segments from various depths

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ABSTRACT

Silverleaf nightshade (*Solanum elaeagnifolium* Cav.) is a widespread deep-rooted summer-growing perennial weed. It is considered amongst the worst weeds of cropping and pasture systems. The extensive root system of silverleaf nightshade competes both directly and indirectly with summer and winter pastures/crops, respectively, through depletion of soil moisture and other resources.

Silverleaf nightshade is capable of forming new plants from both seeds and root segments. It is believed that cultivation is a major factor contributing to the spread of silverleaf nightshade. To determine the importance of cultivation in the spread of silverleaf nightshade, a glasshouse experiment investigated the response of various lengths of silverleaf nightshade root when buried at several depths.

Reduced cultivation systems may decrease the spread of silverleaf nightshade. Results indicate that silverleaf nightshade can regenerate from root segments as short as 1 cm. Significantly more shoots are produced from 10 cm root segments at all depths compared to shorter root segments. No mortality was observed for 10 cm root segments, whereas mortality significantly increased as segment length decreased. However, despite the increased mortality of shorter segments, increasing fragment size did not reduce overall shoot density.

These findings have implications for how a paddock infested with silverleaf nightshade should be managed. Minimum tillage techniques should be used when any sowing operations are undertaken. It would also be crucial that all implements are thoroughly cleaned prior to moving machinery out of an infested field, as even short root segments should be considered viable and therefore capable of starting a new infestation in a clean field.

INTRODUCTION

Silverleaf nightshade (*Solanum elaeagnifolium* Cav.) is a deep-rooted, summer-growing perennial weed of the Solanaceae family that grows in the cropping/pasture zone of southern Australia. Silverleaf nightshade arrived in Australia in the early 1900s as a contaminant of grain and fodder (Parsons and Cuthbertson 2001). Isolated patches of the weed appear to increase in size slowly (Moore *et al.* 1975) and it was not until the 1960's that silverleaf nightshade became an important weed (Cuthbertson *et al.* 1976).

Surveys report that silverleaf nightshade infested nearly 22 000 ha in south-eastern Australia in the early 1970s, with 90% on the infested land being used for agricultural purposes (McKenzie 1976). There was a five-fold increase in area infested within twenty years, with 140 000 ha infested by 1992 (Heap and Carter 1999). Silverleaf nightshade is a declared noxious weed in mainland states of Australia where it occurs and is difficult to eradicate once established.

Worldwide, silverleaf nightshade is a significant weed of cotton and grain sorghum (Boyd and Murray 1982) and wheat and lucerne (Boyd and Murray 1982, Hoffmann *et al.* 1988) and can cause important economic losses. Grain yield losses of 12% were reported from Australia as a result of an infestation of nine plants/m^2 (Leys and Cuthbertson 1977). Yields from North American cotton crops indicate less effect by silverleaf nightshade when irrigated, suggesting that competition for moisture is a significant factor (Green *et al.* 1988). Silverleaf nightshade currently costs meat and wool producers more than $10/ha per year and has been estimated to cost South Australian producers more than $10 million.

Asexual reproduction has been recorded as more important than sexual reproduction in similar perennial weeds such as polymeria take-all (*Polymeria longifolia* Lindley) (Johnson and Sindel 2005. Seed and root segments are dispersal mechanisms for silverleaf nightshade (Wapshere 1988, Richardson and McKenzie 1981), but the relative importance is not fully understood. Seed can be dispersed by livestock by attachment to fibre or via ingestion, mechanically by attachment to vehicles or machinery and naturally via wind or water movement. Root segments may be dispersed as a contaminant of agricultural produce or attached to machinery (Gmira *et al.* 1998, Wapshere 1988).

The extensive root system consists of a main vertical taproot to depths of 2 m or more (Monaghan and Brownlee 1979, Richardson 1979, Richardson and McKenzie 1981) and numerous lateral roots in the upper soil layers. Cultivation can lead to root fragmentation and therefore plays an important role in increasing the density of silverleaf nightshade infestations. The type of cultivation will influence root segment size and burial depth. Previous research (Richardson and McKenzie 1981, Boyd and Murray 1982) reports the effect of single burial depths on regeneration of shoots, but the interaction between burial depth and root segment length is not clearly understood. The aim of this study was to determine the ability of various lengths of taproot to regenerate from different depths in the soil. It is hypothesised that reduced cultivation will reduce the opportunity for silverleaf nightshade root regeneration.

METHODS

Silverleaf nightshade roots were collected in October 2006 from a cropping field adjacent to the Devlin's Bridge Road, Narrandera, NSW. The field is on a light sandy loam and had an average silverleaf nightshade infestation of 5.5 shoots/m^2. Root material was located by the presence of dead shoots and was exhumed by shovel, dead aerial growth removed at the crown and the roots placed in a plastic container with moist soil. Roots were stored at 4 C for several days until planted.

A randomised compete block design with six replicates was used with two variables, root segment length (1, 2.5, 5 and 10 cm) and root burial depth (2.5, 5 and 10 cm).

A 10 cm root harvested from the uppermost portion of the root was used for each pot. These root sections were cut into ten, four and two segments respectively for the 1, 2.5 and 5 cm length treatments. Each segment was weighed and callipers used to record the diameter in the centre of the segment. Segments were then placed into 20 cm diameter pots partially filled with sandy loam. Root segments were then covered with the appropriate amount of a 4:1 mixture of sandy loam and potting mix to achieve burial depths of 2.5, 5 and 10 cm.

Pots were maintained in a glasshouse and watered regularly. Shoot emergence was recorded weekly for each root segment. Pots were maintained for six months to simulate a normal growing season. At the completion of this time, aerial growth was harvested at ground level and maximum shoot height and total fresh weight recorded. Root segments were exhumed, washed of excess soil and blotted dry. Maximum root length and weight of roots were recorded.

Root segments that had lost weight during the experiment were classified as dead. Root segments that had not lost weight or had produced shoots were classified as alive. Mortality for each pot was determined as the percentage of dead root segments in the pot.

Data were analysed using analysis of variance and post hoc Fishers tests used to determine statistically different means.

RESULTS

Root segments buried at 10 cm soil depth took longer to emerge than the shallower burial depths of 2.5 cm and 5 cm. Shoot emergence commenced within two weeks of burial at 2.5 or 5 cm depth, and within three to four weeks for 10 cm depth (Table 1). Emergence for 1 cm length segments only occurred from 5 cm depth.

Burial depth had a significant effect on the number of emerged shoots ($P<0.05$). Where emergence occurred, segment lengths less than 10 cm produced the most number of shoots per segment when buried at 5 cm depth (Table 2). Root segments 10 cm long produced more than one shoot each, with the most shoots produced from 2.5 cm burial depth.

Table 1. The effect of root segment length and burial depth on time to shoot emergence.

Root length (cm)	Burial depth (cm) 2.5	5	10
	Time for first shoot emergence (weeks)		
1	-	2	-
2.5	2	2	4
5	2	2	3
10	2	2	3

Table 2. The effect of root segment length and burial depth on number of shoots produced per root segment length.

Root length (cm)	Burial depth (cm) 2.5	5	10
	Average number of shoots*		
1	-	0.4 [a,b]	-
2.5	0.5 [a,b]	1.1 [b,c]	0.2 [a]
5	0.5 [a,b]	1.0 [a,b,c]	0.3 [a,b]
10	2.8 [e]	2.2 [d,e]	1.7 [c,d]
LSD ($P<0.05$)		0.8	

* Different letters represent significant difference according to Fisher's protected LSD ($P<0.05$)

Root segment mortality was significantly affected by segment length ($P<0.05$). No root mortality was observed for 10 cm segments at any depth (Table 3). Root mortality significantly increased with decreasing segment length, with 80% mortality observed for 1 cm root segments ($P<0.05$). Burial depth influenced mortality of 2.5 and 5 cm root segments, with higher mortality observed at 10 cm depth.

Table 3. The effect of root segment length and burial depth on mortality levels.

Root length (cm)	Burial depth (cm) 2.5	5	10
	Mortality (%)*		
1	72 [a,b]	75 [a,b]	80 [a]
2.5	46 [b,c]	46 [b,c]	67 [a,b]
5	8 [d]	33 [c,d]	58 [a,b,c]
10	0 [d]	0 [d]	0 [d]
LSD ($P<0.05$)		33	

* Different letters represent significant difference according to Fisher's protected LSD (P<0.05)

Live root segments produced larger fresh weight of shoots and additional roots as the initial segment length increased (Table 4). Segments less than 10 cm length produced the most growth at 5 cm burial depth, whereas 10 cm segments produced significantly more biomass at all burial depths.

Where root segments were deemed to have died, 1 cm length segments lost 60-70% of their weight and 2.5 cm lengths lost 40% of their weight at all depths (data not shown). Roots 5 cm long did not lose weight at 2.5 cm depth but lost 60% of their weight at 10 cm depth. No mortality was observed for roots 10 cm in length.

Table 4. The effect of root segment length and burial depth on root and shoot weight gains for live root segments.

Root length	Burial depth (cm)		
(cm)	2.5	5	10
	Fresh weight gain for live roots (g)[A]		
1	0.0 [a]	2.8 [a,b]	0.0 [a]
2.5	1.9 [a,b]	8.3 [b,c]	0.7 [a]
5	4.4 [a,b]	8.4 [b,c]	6.8 [a,b]
10	23.6 [e]	14.4 [c,d]	17.6 [d,e]
LSD (P<0.05)		7.0	
	Fresh shoot biomass (g) [B]		
1	0.0 [a]	1.2 [a,b]	0.0 [a]
2.5	1.6 [a,b]	3.5 [a,b]	1.2 [a,b]
5	3.2 [a,b]	6.0 [a,b]	7.0 [b]
10	20.7 [d]	13.7 [c]	12.2 [c]
LSD (P<0.05)		6.2	

[A] Different letters represent significant difference according to Fisher's protected LSD (P<0.05)
[B] Different letters represent significant difference according to Fisher's protected LSD (P<0.05)

DISCUSSION

Silverleaf nightshade roots of 10 cm in length readily produce one or more shoots. Fragmentation into smaller segments, through cultivation of a field, can provide increasing mortality of individual segments as segment length decreases. However, the number of segments created negates the increased mortality levels, resulting in more new plants being created as a consequence of cultivation.

The optimal depth for regeneration of silverleaf nightshade from root segments was 5 cm, with segments as short as 1 cm capable of producing shoots. Shallower burial approximately halved the number of shoots produced and the weight gained for 2.5 and 5 cm long segments. Similarly, Boyd and Murray (1982) reported that 1-3 shoots are produced from 5 and 10 cm long root segments respectively when buried at 8 cm depth in the field, with significantly more shoots produced from 15 and 20 cm long root segments.

One centimetre segments did not produce any shoots at shallow depths, possibly due to the more extreme fluctuations in temperature and moisture levels. Burial of 1 cm length to 10 cm also prevented regeneration. Richardson and McKenzie (1981) reported that 0.5 and 1.0 cm root lengths produce 0 and 0.2 shoots per segment respectively when buried at 2 cm in pots in a glasshouse.

Root segments less than 10 cm in length produced less biomass of roots and shoots during the period of this experiment. The reduction in vigour may lead to less seed production per plant in that season. However, if allowed to become established, the plant will most likely produce seeds in subsequent seasons. It is important that any new plants created as a result of cultivation are controlled. The reduced biomass of plants derived from small root segments may lead to the plants being more susceptible to control with herbicides.

Fragmentation of roots can be accomplished by rotary hoes or multiple passes with discs (Culpin 1981), however this level of cultivation has a severe adverse effect on soil structure. To achieve any reduction in silverleaf nightshade populations, segments would also need to be buried to at least 10 cm depth. The inability to control burial depth and the impact of cultivation on soil structure suggest that cultivation should be minimised in fields where silverleaf nightshade occurs.

TAKE HOME MESSAGE

Reduced cultivation systems will retard the spread of silverleaf nightshade infestations.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the financial support of Meat and Livestock Australia to conduct this research.

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