Small-seeded dodder (*Cuscuta planiflora* Ten.), a new weed threat to Australian agriculture

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Summary Small-seeded dodder is an annual, twining stem holoparasite of the family Cuscutaceae that has recently been found in Australian canola and lupin crops for the first time.

Small-seeded dodder is a serious pest of lucerne in the United States of America and is also known to infest a number of other broad acre and horticultural crops. Infestation by small-seeded dodder results in yield losses due to reduced flower/fruit size and seed production, or death of the host plant. In addition, there may be increases in per unit production costs due to control or seed cleaning costs, and reduced crop marketability.

Small-seeded dodder reproduces solely by seed, which can remain viable in the soil for up to twenty years, resulting in difficulty in eradication. Control measures for small-seeded dodder are limited, because the control treatments are usually damaging to the host.

Small-seeded dodder has strong potential to become a serious agricultural weed in Australia due to the suitability of the climate, presence of host species, availability of pollination and dispersal vectors and the lack of restricting factors such as natural predators.

Keywords Canola, holoparasite, lucerne, *Medicago sativa* L., small-seeded dodder, *Cuscuta planiflora* Ten., trifluralin.

INTRODUCTION

Small-seeded dodder, also known as alfalfa dodder, is a stem holoparasite belonging to the family Cuscutaceae. It grows only by penetrating tissues of host plants to obtain water and nutrients.

It is not known how long small-seeded dodder has been present in Australia. The first verified Australian specimens of small-seeded dodder were collected in 1947 from Fitzroy Gardens in Melbourne. Small-seeded dodder appeared again in South Australia in 1982 at Fairview Conservation Park and in the Austin Botanical District of Western Australia in 1986. Further infestations have subsequently been found in a wide range of soil and vegetation types (Western Australian Herbarium 1998).

Small-seeded dodder was discovered parasitising canola crops for the first time, in the Geraldton area of Western Australia in 2001 and later in a lupin crop in the Nanson area. In both crops, the result was stunted crop growth.

While numerous studies of dodder species have been undertaken, the authoritative reference remains that by Dawson *et al*. (1994), which is relied heavily upon in this assessment.

Description Small-seeded dodder has yellowish or crimson, twining, terete stems up to 0.3 mm wide, with leaves absent or reduced to minute scales. Subsessile, 5- (or rarely 4-) merous flowers form in a compact inflorescence and are up to 3 mm long, whitish and somewhat fleshy. The calyx is broadly campanulate with obtuse or acute, fleshy or turgid lobes and almost encloses the corolla tube. The corolla is broadly campanulate to globose, with slightly obtuse, spreading lobes that may be turgid or membranous at the apices. Within the corolla tube, the stamens are subtended by fimbriate scales, which almost reach the stamens or are shorter. Scales are fringed, usually oblong and/or bifid and bridged low down or at the middle. Stamens are shorter than the corolla lobes with filaments that may or may not be equal in length to the anthers. The two styles may be longer or shorter than the subulate stigmas, and are slender above a globose, two-celled ovary. The capsule is depressed-globose, splitting around the base. The four ovoid, granulate seeds are mostly shorter than 1 mm.

Life history Dodder species are annual plants that reproduce solely through seed. Unlike other parasitic plants, dodder seedlings germinate throughout the year, without stimulation by a host species, providing that there is sufficient soil moisture for germination and three to six centimetres of growth (Dawson *et al.* 1994). Seedlings germinate on or near the soil surface and do not produce roots but instead produce a single stem that develops upward without leaves and twines around any nearby vertical object (Dawson *et al.* 1994). If no suitable host is encountered within several days, the seedling will die (Dawson *et al.* 1994). The seedling entwines about the host stem and produces haustoria that penetrate the surface through enzymatic action. This enables the parasite to draw water and nutrients from the host (Dawson *et al.* 1994). The portion of the seedling's stem that developed below the initial

penetration point will then die off as it is no longer needed by the plant (Dawson *et al.* 1994). In small-seeded dodder, the stems continue to develop, branching and twining through the host plant, developing more haustorial attachments and spreading to adjacent plants. Flowering of small-seeded dodder occurs in summer from January to May (Meeuse and Welman 2000) but with considerable variation between subtaxa. Seed set occurs within a month of flowering (Salle *et al*. 1997). Seed of dodder species has a hard seed coat that is broken down over time through natural processes (Dawson *et al.* 1994). Dodder seed can remain viable in the soil for up to 20 years, with germination of seedlings occurring periodically under favourable environmental conditions (Dawson *et al.* 1994). Scarification of the seed coat at the time of sowing of the host crop may trigger a flush of dodder germination. Dodder dies off annually with senescence of the host or in response to frost (Dawson *et al.* 1994).

Zaki *et al*. (1998) conducted germination trials for dodder and determined that the optimum temperature for germination is 30°C. Neutral or slightly alkaline media were determined to be the most suitable for the germination of dodder seeds.

Dispersal Seeds of dodder species are usually dispersed close by the parent plant. Wind has little effect on the dispersal of dodder seed due to the seed weight and shape (Dawson *et al.* 1994). Seed may pass through birds or mammals and be spread through their movement and deposition of faeces (Lee and Timmons 1980, Anon. 2000). Seed may also be distributed in mud or manure adhering to fur, feathers or feet of animals (Cooke 2001).

Anthropogenic dispersal of dodder seed is known to be primarily through contaminated crop seed (Parker 1991, Dawson *et al.* 1994). The seeds are small and are easily confused with those of clover or lucerne, making seed cleaning difficult and expensive. Other recorded methods of spread of dodder species include fodder movement, soil movement on livestock or machinery and seed spread through irrigation water or run-off. Seed may potentially pass through stock and be spread through stock movement or through the mechanical spreading of contaminated manure (Lee and Timmons 1980).

Symptoms of infestation Dodder species draw water and nutrients from their host, leading to a reduction in growth and development of the host plant. This may reduce flower/fruit size and seed production or cause death of the host plant.

Presence of strands of dodder on the plant is the primary symptom of infestation. In some hosts, yellowing or reduced flowering/fruit set may be observed however these symptoms have not been documented. From a distance, large infestations of dodder may appear as a whitish (flowering), yellow or orange area in a crop, due to the presence and colour of the parasite on the crop. When flowering, the dodder has an appearance reminiscent of cotton wool, covering the host plant.

Host range The worldwide host range of small-seeded dodder is not known but is expected to be wide ranging, due to the adaptability of this genus. Documented occurrences of small-seeded dodder include its presence on citrus, grapes, many legumes (including faba beans, *Indigofera* spp., lucerne, melilotus and clover), solanaceous vegetables (including eggplant, tomato and capsicum), onion and other monocots, *Barleria* spp., *Merremia* spp., cucumber, chrysanthemum and sugar beet. Non-crop hosts include *Centaurea* spp., *Plectanthrus* sp., *Solanum* spp., *Rumex* spp. and *Senecio vulgaris* (Orloff *et al*. 1989, Sher and Shad 1989, Parker and Riches 1993, Zaki *et al*. 1998, Meeuse and Welman 2000, Cooke 2001). Parasitisation of monocots by dodder species is uncommon, with grasses usually being immune, but there are records of attachment to asparagus and onion by some species (Dawson *et al.* 1994).

Small-seeded dodder has been found parasitising canola, lupins and some native species in Australia but its potential host range is significantly greater. The occurrence of small-seeded dodder on canola has not been documented previously and may be a varietal anomaly (either of the dodder or the canola).

Distribution Small-seeded dodder is a native of the Mediterranean region which has become naturalised in more than forty countries including Australia (present in South Australia, Victoria and Western Australia), the United States of America and numerous nations in Europe, Asia and Africa.

Agricultural impact Dodder presence in a crop may reduce flower/fruit size and seed production or cause death of the host plant, all of which can result in yield losses.

The presence of dodder in fodder crops may lower marketability due to seed presence and reduces the fodder quality as well as reducing yield and lengthening curing time (Orloff *et al*. 1989). Dodder seeds may contaminate seed crops, resulting in reduced marketability of the seed crop and higher seed cleaning costs (Parker 1991). Presence of dodder seeds may result in rejection of the commodity by some countries that do not have the weed.

Small-seeded dodder is a serious pest of lucerne in the United States of America and is also known to infest a number of other broad acre and horticultural crops though there is no record of it being an economic problem in these.

Environmental impact Dodder species have a wide host range and are known to invade native vegetation. This may significantly impact on biodiversity in infested areas. Control of dodder species commonly involves host death and is not practical for control of large infestations in native vegetation.

Dodder infestations are a hindrance to wildlife movement through their ability to close off areas of bush with dense net like vegetation masses. Small animals may become entangled in dodder, leading to their death from thirst or starvation.

There are several Australian native species of dodder that might be adversely affected by control of exotic dodder species.

Human health impact There are no known health problems associated with dodder (Dawson *et al.* 1994) though it presents a minor tripping hazard.

Containment of infestations In order to prevent the spread of small-seeded dodder, clean, certified seed should be used and livestock should not be fed contaminated fodder. Contaminated fodder should be destroyed. If livestock are fed contaminated fodder or have been grazing in a contaminated area, they should be confined to that area or maintained in quarantine until all seed has passed from their system. Contaminated manure should not be spread on uninfested soil. Harvest of infested areas may result in spread of the infestation by the harvesting equipment and should be avoided. All vehicles and equipment should be cleaned prior to leaving infested areas. Dodder should be controlled on irrigation ditches, tracks and fence lines to prevent spread between cultivated areas as well as to reduce seed movement through run-off.

Chemical control Control of dodder species using herbicides is frequently ineffective and often results in host death. One of the most successful strategies is that reviewed by Cudney *et al*. (1992) who suggest control of large-seeded dodder (*Cuscuta indecora* Choisy) in lucerne with trifluralin, a method that is largely applicable to canola and pulses as well as having relevance for other crops. Trifluralin granules applied pre-emergence result in a high percentage kill of the dodder but are only effective for a few weeks. Dodder plants that survive trifluralin application will grow enough during the season to reduce the yield to levels that are similar to those experienced with no control (Orloff *et al*. 1989). For this reason, Cudney *et al*. (1992) advocates additional late-season control to prevent seed set. Late-season control can involve burning smaller patches or selective chemical control where large infestations occur and an eradication program is not in place.

Herbicides are more effective if translocated from the host plant to the dodder rather than applied directly to the dodder foliage. Translocated herbicides kill the haustoria, which the dodder might otherwise regenerate from (Dawson *et al.* 1994). In lucerne, low levels of glyphosate (75–150 g ha^{-1}) will act as a selective control (Dawson 1990). Partially selective control of dodder species in other crops with low-level glyphosate application has also been seen (Abu-Irmaileh and Saghir 1994).

There is a wide range of other herbicides known to control dodder species in a variety of crops, with varying levels of effectiveness.

Fumigation of the soil to destroy seed in the soil is an expensive option that should be considered in an eradication program where there are low levels of infestation.

Mechanical/cultural control In long term management of dodder species, containment and prevention of seed set are the most important aspects of managing infestations. Seed set prevention is critical because removal of the long-lived seed from the soil may take twenty years or more. The soil seed bank can be reduced through rotation with a non-host monocot crop for a long time period, providing that strict control of broad-leafed weeds in the crop is carried out to prevent the dodder finding a host (Dawson *et al.* 1994).

Burning of crops to destroy fruiting dodder is a useful mechanism for the control of seed production (Cudney *et al*. 1992). It also kills seeds present on the soil surface.

In orchards, pruning of infested branches is the most effective method of controlling dodder that is attacking the crop (Dawson *et al*. 1994). In row crops, repeated tilling is a useful method of destroying germinating dodder seedlings between rows (Dawson *et al*. 1994). A reduction in dodder seedling emergence of some 99% has been achieved in large-seeded dodder through burning of the crop and parasite (Cudney *et al.* 1992).

Cool temperatures retard dodder growth, so careful timing of crop sowing can reduce levels of infestation (Dawson *et al.* 1994).

Biological control Little research has been carried out with regards to potential biological controls for

dodder though there has been some success in China in controlling dodder species with the fungus *Colletotrichum gloeosporiodes* (Dawson *et al.* 1994). Biological control of dodder in Australia is risky due to the presence of native dodder species that might be adversely affected.

DISCUSSION

Potential distribution in Australia Dodder is largely unrestricted by climate and may grow wherever suitable host species are found. The potential distribution of small-seeded dodder in Australia is unknown due to the lack of information available on host species. Small-seeded dodder could reasonably be expected to grow throughout most of Australia if suitable cropping is undertaken or native hosts are present.

Climate modelling indicates that the areas at most risk from infestation by small-seeded dodder are coastal or high rainfall areas of the south of Australia and inland areas of Queensland, (Randall 2001).

Probability of spread The spread of small-seeded dodder in Australia is almost certain if no containment measures are undertaken. Spread of dodder species has been observed to be rapid overseas in the presence of appropriate hosts.

Eradication potential Eradication of small-seeded dodder in Australia is unlikely to be successful given the presence of small-seeded dodder on native hosts in crown land, from which it is able to reinfest clean areas. Control of small-seeded dodder in native vegetation is impractical due to accessibility and funding problems. The longevity of the seed in the soil also reduces the likelihood of successful eradication. Containment of infestations to prevent further spread is a primary consideration.

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