Two biological control options for *Sonchus oleraceus* in Australia

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Summary Common sowthistle, *Sonchus oleraceus* (Asteraceae), is a widespread invader of disturbed ecosystems in Australia. It is a major weed of Australian cropping systems, its incidence having increased over the past two decades. Surveys of this weed throughout Australia have found two organisms on *Sonchus* spp. that are very damaging; an undescribed species of eriophyid mite (*Aceria* sp.) causing extensive leaf-rolling damage and a rust fungus, *Miyagia pseudosphaeria*. Both appear to be specific to *Sonchus* spp. and could be considered for a conservative approach to biological control. The interactions of these two organisms with the weed species and the only native sowthistle species in Australia, *Sonchus hydrophilus*, are being investigated to establish the origins of these organisms and likely impact, both in natural and cropping ecosystems.

Keywords Eriophyid mite, rust fungus, sowthistle.

INTRODUCTION

Common sowthistle, *Sonchus oleraceus* L. (Asteraceae), is a common weed of disturbed ecosystems throughout Australia. It is a major weed of Australian cropping systems, especially those of south east Queensland and northern NSW, with grower surveys of the region labelling it as one of the main weeds of the area (Walker *et al.* 2005, Chauhan *et al.* 2006). Its incidence is increasing largely due to growers adopting conservation tillage and the evolving resistance of the weed to chemical controls such as chlorsulfuron and atrazine (Adkins *et al.* 1997).

Biological control is being investigated as an alternative for this weed. Sowthistles have already been the target for biological control in Canada (Peschken 1984). The origin of *S. oleraceus* lies in Europe. Preliminary surveys for biological control agents have been made in southern France (Scott and Jourdan unpublished) to complement northern European surveys made for the Canadian study (Peschken 1984). However, before any biological control project can be implemented, it is advisable to determine what organisms are already present in Australia. In 2007, we initiated field surveys of the introduced *Sonchus* spp. and the only native congener, *S. hydrophilus* Boulos. Surveys were conducted throughout south-west Western Australia and south-east Queensland to identify organisms associated with *Sonchus* spp. Two organisms of interest were regularly isolated from diseased plants. Preliminary studies of these species are reported here.

MATERIALS AND METHODS

The life cycle of the two important organisms isolated during surveys (*Miyagia pseudosphaeria* (Mont.) Jorst. (Uredinales: Pucciniaceae) and *Aceria* sp. (Acari: Eriophyidae)) were monitored throughout the year at two study sites: Star Swamp (31.853°S; 115.759°E) and Perry Lakes (31.943°S; 115.785°E). Within each of these sites, one moist and one dry area were chosen which were separated by approximately 200 m of bushland.

Repeatable inoculation techniques are being developed for the rust and are already established for *Aceria* sp. This enables testing to proceed on the latter species.

A no-choice host specificity test determined the specificity of *Aceria* sp. within the Lactuceae tribe. Subtribes tested included Sonchinae (*S. asper* (L.) Hill, *S. hydrophilus*, *S. oleraceus*, *Actites megalocarpus* (Hook.f.) Lander), Hyoseridinae (*Cichorium endivia* L., *C. intybus* L.), Lactucinae (*Lactuca sativa* L.), Crepidinae (*Taraxacum officinale* F.H.Wigg.) and Hypochaeridinae (*Hypochaeris radicata* L.). Results were complemented with field observations.

To measure the impact of *Aceria* sp. on *S. oleraceus* and the native species *S. hydrophilus*, plants with more than eight leaves (and <12 leaves) were inoculated with 100 mites per plant. To gain a preliminary understanding of the effect of age on mite infestation, *S. oleraceus* seedlings (less than eight leaf stage) were also inoculated.

RESULTS

Miyagia pseudosphaeria

The rust fungus, *Miyagia pseudosphaeria*, was the most frequently encountered organism on *S. oleraceus* and was found widespread across southern and eastern Australia. The rust is autoecious. Uredospores and aeciospores were common on stems and leaf adaxial and abaxial surfaces. At Star Swamp and Perry Lakes, during the winter period when *S. oleraceus* was absent, the rust did not appear on *S. hydrophilus,* a perennial species at these sites. The rust returned to all sites, moist and dry, with the growth of new *S. oleraceus* plants in the spring. Teliospores were rare on field material examined by microscopy and were never seen at Star Swamp or Perry Lakes field sites.

Field observations indicated that *M. pseudosphaeria* was capable of infecting *S. asper*, *S. oleraceus* and *S. hydrophilus*, however infection of *S. hydrophilus* was rare and when infected, damage was minimal. Infection of *Actites megalocarpus* (Hook.f.) Lander, (a native of the Sonchinae subtribe) has not been observed under field conditions despite it occurring within the distribution of the mite and its hosts.

Aceria sp.

The observation of widespread and extensive leaf-rolling damage on *S. oleraceus* leaves led to the discovery of a second organism of interest, an eriophyid mite. This has since been identified to genus level as an undescribed species of *Aceria* (D.K. Knihinicki, NSW Dept. of Primary Industries pers. comm.). It appears to be present throughout Australia but its distribution is irregular, both between areas and also within sites with only some plants affected. The mite was found in WA, Vic and Qld.

Analysis of mite sizes showed four life stages (egg, larva, nymph and adult (Manson and Oldfield 1996)) present on infected material. The adult stage appeared to have three different sizes. The mite was always present at both the moist Star Swamp and moist Perry Lakes sites where it continued to infest *S. hydrophilus* plants throughout the year. However, the mite was never observed at the Star Swamp dry site. *Aceria* sp. was initially found at the Perry Lakes dry site, but with the absence of *Sonchus* spp. during the dry summer period, mites were not observed again during the course of the study even with the return of *Sonchus* spp. towards the end of winter.

No-choice host specificity testing revealed that *Aceria* sp. was unable to cause damage to closely related species within the Lactuceae tribe including *Actites megalocarpus*. *Sonchus oleraceus*, *S. asper*, and *S. hydrophilus* were all damaged when infested with *Aceria* sp. This was supported by field observations.

Aceria sp. significantly reduced the growth of *Sonchus* spp., particularly, *S. oleraceus* (Figure 1). An 89% growth reduction occurred if *S. oleraceus* plants were infected at the seedling stage, 70% reduction if inoculated after they had reached the eight leaf stage. Growth reduction of *S. hydrophilus* was 32%.

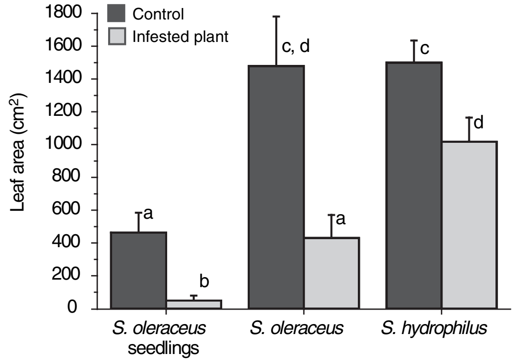

Figure 1. The effect of *Aceria* sp. on the growth of *S. oleraceus* seedlings and plants (inoculated at <8-leaf growth stage and >8-leaf stage respectively) and mature *S. hydrophilus* plants. Bars = standard error; columns with different letters indicate significant difference.

DISCUSSION

Miyagia pseudosphaeria and *Aceria* sp. appear to be highly specialised species with a close association with their host, *S. oleraceus*. Both organisms are specific to *Sonchus* spp., neither infecting *Actites megalocarpus* (Sonchinae subtribe) in the field nor, in the case of *Aceria* sp., other closely related species within the tribe Lactuceae under glasshouse no-choice trials. Both organisms complete their lifecycle on one host. In the Australian context, these organisms would be considered for the conservative approach to biological control (Wapshere *et al.* 1989, for an example see Kluth *et al.* 2005). This approach involves applying management options based on an understanding of the biology that maximises the agent's damage on the weedy hosts.

Miyagia pseudosphaeria has a world-wide distribution and probably originates from Europe or north Asia. It has spread from there to arrive in New Zealand (1919) and Australia (1953) (McKenzie and Johnston 2004) and more recently in North America (2002) (Hernandez *et al.* 2003). It has been suggested that the spread is due to the appearance of a more virulent strain (McKenzie and Johnston 2004). Genetic variation studies of *M. pseudosphaeria* will aid our understanding of variation in the pathogen to help determine its origins and whether or not importation of further strains are warranted.

A second aspect requiring investigation is the mechanisms of dispersal and survival in the absence of the host. While *M. pseudosphaeria* was seen to produce teliospores which are long term survival structures for rust fungi, these were only rarely observed. Having not observed teliospores or infection of the native *S. hydrophilus* at the Star Swamp or Perry Lakes field sites, it is likely that the pathogen relies on wind dispersal mechanisms for its distribution rather than alternative *Sonchus* hosts or soil survival mechanisms for infection of germinating *S. oleraceus*.

The survival and dispersal mechanism of the eriophyid mite are also unknown. However, measurements of the size of the mites indicated that there could be three different adult types; male, female and a 3rd adult type, the deutogyne female (a survival mechanism for when the host is absent) (Manson and Oldfield 1996). This requires further investigation.

Pathogenicity trials of the eriophyid mite showed a significant growth reduction in infested plants of both *S. oleraceus* and *S. hydrophilus*. The origin of *Aceria* sp. is unknown and it is possible that it has evolved with the native *S. hydrophilus*, which may explain why the native species is not affected by the eriophyid mite to the same extent as the weedy *S. oleraceus.* This implies that the mite could be a 'new association' on *S. oleraceus* and the greater impact observed on the introduced versus native species could be an example matching the concept of homeostasis, regarded by Dennill and Hokkanen (1990) as a central feature of biological control. Alternatively, genetically based adaptations may underlie the impact and host shift of the mite and the plant's reaction to the mite (Carroll 2007).

Eriophyid mites and rust fungi are well known for their host specificity which makes *Aceria* sp. and *M. pseudosphaeria* good potential biological control options for Australia and elsewhere in the world. In Australia, both may be considered for a conservative approach to biological control.

ACKNOWLEDGMENTS

This research has been funded by the CRC for Australian Weed Management and CSIRO.

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