Better management of *Sonchus oleraceus* L. (common sowthistle) based on the weed’s ecology

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**Summary** *Sonchus oleraceus* L. (common sowthistle) was recently identified in a survey as the most common weed of the sub-tropical grain region of Australia. In addition, the weed was identified as having a moderate risk of developing resistance to glyphosate, while populations already have resistance to Group B herbicides. Hence, *S. oleraceus* is a weed that not only requires better management but also strategies that reduce the risk of resistance to herbicides. Weed ecology was investigated closely to assist devising management strategies. In particular, seed germination, emergence, persistence, dormancy, and production, as well as plant morphology, competition in crop, and response to tillage were studied. The characteristics that are important for better management of this weed are the weed’s prolific seed production, the ability of this seed to germinate all year round and the ability of the weed to grow and produce seed across diverse environments. An integrated and sustainable approach to management of *S. oleraceus* should include growing competitive crops, strategic tillage, follow up herbicide applications, and rotation of herbicide groups especially for Group B and M herbicides.

**Keywords** *Sonchus oleraceus*, sowthistle, ecology, management.

**INTRODUCTION**

In a recent survey of growers and agronomists in the subtropical grain region of Australia, *Sonchus oleraceus* L. (common sowthistle) was identified as the most common weed, nominated by 52–80% of respondents across cropping zones (Osten et al. 2004). *S. oleraceus* was most prevalent in winter and summer fallows and winter crops (Widderick et al. 1999 and Osten et al. 2004), and was recognised as a greater problem in conservation tillage systems (Widderick et al. 1999). The weed was also common in non-crop areas such as roadsides and gardens.

*Sonchus oleraceus* developed resistance to Group B herbicides following the repeated use of chlorsulfuron in southern Queensland and northern New South Wales (Adkins et al. 1997). In addition, the recent survey by Walker et al. (2004) identified this weed as having a moderate risk of developing resistance to Group M (glyphosate) herbicides, as this herbicide is often relied upon alone to control this weed.

This paper reports on a study aimed at elucidating the ecology of *S. oleraceus* to assist in the devising of better management strategies for the weed.

**MATERIALS AND METHODS**

A series of glasshouse, field and laboratory experiments was completed on the ecology of *S. oleraceus* in the subtropical grain region.

**Germination** Seeds from different populations were germinated at different water potential (0 to −1.4 MPa), temperature (5–35°C), and light (+/−) combinations in growth cabinets.

**Emergence and seed persistence** Seed were buried at different depths (0–10 cm) in pots placed in the field. Emergence was monitored over 30 months, and seed were exhumed at 2–6 month intervals, and tested for viability under an ideal growth cabinet environment. Seedling emergence was also monitored in the field under different tillage regimes ranging from zero-tillage with stubble to conventional tillage using a disc and chisel plough. After two years, soil samples were taken at 0–2, 2–5 and 5–10 cm depths to test for seed persistence and seed movement.

**Plant morphology and seed production** Seed collected from different populations across the region were grown in a glasshouse. Leaf number, leaf colour, leaf serration, early plant growth habit, capitula number, seed production, time to flowering, and plant height were measured, and populations were compared and grouped according to similarities in morphology. An additional assessment of seed production was taken from an on-farm fallow experiment.

**Seed dormancy** Seeds were collected at maturity from plants in the morphology experiment, and placed for germination in a growth cabinet (20°C, 12 hour light and dark) to assess whether seeds displayed innate dormancy.
Crop competition  Wheat and barley were grown at 25 and 50 cm row spacings and 50, 75, 100 and 150 plants m⁻². Weed biomass and seed production were measured and compared with a situation of no competition (fallow).

Herbicide efficacy  A number of glyphosate and non-glyphosate treatments were assessed, using weed biomass measurements, for weed control in summer and winter fallows.

RESULTS  

Germination  *S. oleraceus* seed germinated readily across a wide temperature range (5–35°C) at a water potential of −1.0 MPa or greater. Germination was optimal at water potentials of −0.4 MPa or greater and no seeds germinated below −1.0 MPa. Germination was favoured in light, although 20% of seed germinated in darkness.

Emergence and seed persistence  *S. oleraceus* emerged all year round from the top 2 cm of soil, with the majority of emergence from the top 1 cm. Very few seeds buried in the top 2 cm of the in-ground pots maintained their viability beyond eight months. Seeds buried deeper than 2 cm persisted for up to 30 months.

Emergence was greatest under zero tillage systems, which had a greater number of seeds persisting in the top 2 cm of soil than systems with tillage (Figure 1).

Plant morphology  *S. oleraceus* displayed diverse morphology both within a population and between populations, suggesting great genetic diversity.

Seed production  *S. oleraceus* has a great capacity for seed production with up to 8000 seeds produced per plant in a glasshouse environment and on average 68,340 seeds m⁻² in a winter fallow.

Seed dormancy  Seeds germinated readily (65–100%) soon after harvest, demonstrating little innate dormancy.

Crop competition  A competitive crop, such as barley, or wheat grown at narrow row spacing (25 cm) and high plant density (≥100 plants m⁻²) greatly reduced the number of *S. oleraceus* plants, their biomass (Table 1) and their potential to set seed.

Herbicide efficacy  Glyphosate alone was effective in controlling *S. oleraceus*. However, glyphosate mixtures, paraquat + diquat, and the sequential treatment of glyphosate followed seven days later by paraquat + diquat were very effective with 98–100% control (Table 2).

DISCUSSION  
An understanding of the strengths and weaknesses of *S. oleraceus* is essential in designing effective management strategies for this weed.

![Figure 1. Effect of different tillage regimes on *Sonchus oleraceus* seed burial and emergence. D – disc plough, B – blade plough, C – chisel plough, Z – zero tillage, S – stubble.](image)

**Table 1.** *Sonchus oleraceus* biomass (g m⁻²) in wheat and barley at different row spacing and crop density.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Row spacing (cm)</th>
<th>Crop density (plants m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0.6</td>
<td>0.03</td>
</tr>
<tr>
<td>50</td>
<td>4.9</td>
<td>2.69</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>50</td>
<td>0.05</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**Table 2.** Effect of herbicides on biomass reduction of *Sonchus oleraceus* (compared with untreated control) in a winter fallow.

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Mode of action</th>
<th>Biomass reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>glyphosate</td>
<td>M</td>
<td>91–98</td>
</tr>
<tr>
<td>paraquat + diquat</td>
<td>L</td>
<td>98–99</td>
</tr>
<tr>
<td>glyphosate + metsulfuron methyl</td>
<td>M + B</td>
<td>100</td>
</tr>
<tr>
<td>glyphosate + 2,4-D</td>
<td>M + I</td>
<td>99</td>
</tr>
<tr>
<td>glyphosate + (triclopyr + picloram)</td>
<td>M + I</td>
<td>100</td>
</tr>
<tr>
<td>glyphosate + (paraquat + diquat)</td>
<td>M + L</td>
<td>100</td>
</tr>
</tbody>
</table>
Aspects of ecology that need to be considered include the weed’s:
• ability to germinate all year round;
• prolific seed production;
• lack of innate dormancy;
• genetic diversity;
• germination from the top 1 cm of soil;
• persistence at depth in soil; and
• poor competitiveness in cereal crops.

As the weed can germinate all year round, diligence and monitoring will be required for its effective management. Since germination is largely dictated by water availability, close monitoring will be required following each rainfall event. Monitoring will be needed in both winter and summer fallows and crops.

The prolific production of seed, which lack innate dormancy, demands that the weed should not be allowed to set seed in either fallow or crop. Any management strategy that can stop seeding and subsequent replenishment of the seed bank will contribute greatly to its effective management. Strategies will require highly effective control techniques as well as management of survivors.

Rapid depletion of the seed bank is favoured in zero tillage systems, where the majority of seeds remain in the top 2 cm of soil. This depth favours seedling emergence. However, depletion of the seed bank is dependent on the complete control of all seedlings for at least eight months to avoid seed bank replenishment.

Current fallow control in zero tillage systems is almost exclusively dependent on herbicides. Efficacy can be improved by treating small seedlings (<3 cm diameter), and applying contact herbicides, such as paraquat + diquat, at higher water volume.

In systems that are not strictly zero tillage, strategic tillage that inverts the soil and buries seeds below 2 cm may be effective in reducing weed emergence. However, no further inversion of the soil should take place for at least 30 months so that persistent seeds are not returned to the top 2 cm of soil. Growers that keep stock may also graze their fallows to control any survivors.

In-crop control should take advantage of the poor competitiveness of this weed. A competitive crop can greatly reduce S. oleracea biomass and seed production. Wheat should be grown at a minimum of 100 plants m⁻² and in a narrow row spacing of around 25 cm. Alternatively, growing a highly competitive crop species, such as barley, will greatly reduce biomass and seed production. Growing a competitive crop will be particularly beneficial in fields with suspected high weed pressures. Conversely, poorly competitive crops such as pulses should not be grown in fields where S. oleracea is known to be prolific.

The genetic diversity of the weed enables it to grow in many habitats and under many different environments. It is important to control S. oleracea plants in non-cropping areas, such as around machinery sheds, fence lines, headlands, water holes and the property boundary to prevent seed spreading into cropping areas.

To reduce the risk of herbicide resistance and to maintain the usefulness of commonly used herbicides, mode of action (MOA) groups should be rotated. In particular, acetolactate synthase inhibiting herbicides such as chlorsulfuron (Group B) should not be used repeatedly and exclusively in winter cereals. Also, glyphosate (Group M) alone should not be used continually for fallow control. Alternative chemical options are glyphosate mixed with an effective herbicide from a different MOA group, such as Group B, C, and I, or effective alternatives from different MOA groups, such as paraquat + diquat (Group L). When there is inadequate control, a follow up treatment with an alternative herbicide MOA or a non-chemical option will manage weed escapes, and thus prevent seed production and seed bank replenishment.

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REFERENCES