THE ECOLOGY OF WILD RADISH : THE KEY TO SUSTAINABLE MANAGEMENT

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Abstract

Wild radish (*Raphanus raphanistrum* L.) is an intractable annual weed of winter crops in southern Australia, and control can no longer be guaranteed by the exclusive use of herbicides. To achieve sustainable and long-term control, weed management must be soundly based, and this review of the ecology of wild radish serves to introduce research which has begun in southern NSW to explore factors which affect the life-cycle of wild radish together with management practices which reduce seedbank populations.

Key words: Population dynamics, wild radish, weed ecology, management

Most weed scientists favour herbicides for weed control because they are effective, cheap, reliable and safe. However, it is increasingly evident that long-term reliance on chemical technology is unsustainable. The short-term benefits from chemical control are offset by problems such as herbicide pollution and resistance (10) that have forced weed science to move toward integrated weed management (IWM) systems. These take advantage of combining the benefits of biological, cultural, mechanical and chemical techniques (1).

The approach to IWM is underpinned by the premise that successful long-term control requires a clear understanding of the biology and ecology of the weed. A useful example is the diagnosis that control of seed production would complement existing practices and result in sustainable population management of wild oats (*Avena* spp.)(14). Subsequently a technique for this has been developed and economically validated (12), providing clear evidence of the success of an ecological approach to improving weed management. This example also illustrates that through understanding a weed?s ecology, the response of populations to selection pressures applied by agricultural practices can be predicted. Other case studies where weed control strategies have been formulated or enhanced through understanding weed biology and ecology are given by Groves (11). However in a recent survey of the extent of basic ecological data pertaining to weeds in Australia, Cousens and Medd (8) reported that the population dynamics of few weeds has been studied systematically.

The Cooperative Research Centre for Weed Management Systems (CRC for WMS) is addressing the need to increase the sustainability of agriculture by developing ecologically based IWM systems, exemplified by wild radish which is becoming increasingly troublesome in annual crops (17, 3, 16) and especially pulses. Herbicides are failing to adequately control it, particularly in broadleaf crops and due to resistance to acetolactate synthase (ALS) inhibiting herbicides in cereals. This review of the population dynamics and ecology of wild radish aims to set directions for future research.

Population dynamics and ecology of wild radish

Wild radish has a life cycle typical of annual species, with plants establishing from seed to produce adult plants, which flower, set seed and die. Its competitiveness along with flexible germination requirements, high reproductive capacity, seed dormancy and seed longevity (5) as well as general crop mimicry all contribute to its success as a weed. These characters enable wild radish seed numbers to build up rapidly and form persistent seedbanks in the soil.

Seed dormancy and longevity are key mechanisms in the persistence of wild radish seed in the soil and in control of the germination process. The exact mechanism(s) of seed dormancy still remains unclear, although both mechanical and chemical factors are known to interact (15, 2, 20). At maturity, most seeds are innately dormant and by the start of the cropping season, as high as 70 % of the seeds are still in a state of dormancy (4). The level of seed dormancy is significantly lower in seed produced from late emerging plants (3, 16), yellow flower types compared with white and purple flower types (2) and plants grown under shorter, relatively drier and warmer growing seasons (e.g. in northern regions of Western Australia) (3). Dormancy is inextricably linked with seed longevity which has been shown to increase with burial depth, the greatest loss in seed viability occurring in the top 1 cm of soil (18, 6). Evidence of wild radish seed remaining viable for up to 20 years (13) needs to be verified.

The consequence of seed existing in dormancy fluxation is a staggered pattern of seedling emergence, which is complicated to predict, and difficult to control. Wild radish responds to alternating light and dark effects generally caused by cultivation and exposure of buried seeds to light (17). Seeds located in the top 1 cm of soil (18, 6) are generally surrounded by more favourable conditions for releasing dormancy such as adequate soil moisture, fluctuating temperatures and vernalisation (17).

Wild radish is phenologically plastic, requiring less than 600 degree-days to flower, with no specific photoperiod requirement (18), allowing it to reproduce in most seasons and environments. How reproduction is affected by interspecific competition is unknown.

As annual plants, wild radish depends on its seed for survival, growth and spread. Seed production is density dependent and can range from 300 seeds/m^2 from 1 plant to over 17,000 seeds/m^2 from 52 plants/m^2 (18). Cheam (3) reported early emerging plants produced more seeds than later emerging plants and Panetta *et al*. (16) reported only the first cohorts produced seed in lupins.

Little is known about the seedbank decline, and understanding this mechanism may be the vital key to better management of wild radish. Losses from mortality, fatal germination, predation and dispersal need to be quantified.

Management Implications

Current management options aim to control emerged populations, ignoring fluxes in other life-cycle processes, such as seedbank dynamics, seed dormancy, seed production, and recruitment. Alternative strategic ways to reducing the seedbank, concentrating on the manipulation of seed dormancy, and the stimulation of germination, need to be tested. For instance, the light/dark response to wild radish germination can be achieved through soil disturbance (7) and emergence patterns regulated by cultivation (7), sowing methods (17, 7) and herbicides (7, 19); all of which is probably due to pod breakdown. Chemical hormones or nitrogenous compounds may be deployed to stimulate germination (9). Most importantly, interactions with environment and management practices on wild radish population dynamics need identifying. Once these are known, an integrated weed management approach to controlling wild radish can be implemented and populations suppressed. Only then will the cost of weed control be reduced and agricultural sustainability be improved.

Research efforts must be increased in seedbank ecology if this weed is to be checked. To this end, research by the CRC for WMS has begun in southern NSW to identify the crucial management practices which reduce seedbank populations.

Finally, whilst some argue that ecological studies do not assist management (19), we would argue they are the ?building blocks? for management. Ecological data can be used to derive mathematical models, to describe for example, tillage effects on seed burial and seedling emergence. More comprehensive population models can be assembled to predict population dynamics in response to management practices and to predict optimal economic management strategies. These assessments can highlight short-term and long-term economic implications of controlling wild radish since benefits from managing seedbanks can only be realised in a long term framework (12).

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