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Arable Extra

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Non-chemical weed management - harvest and the weed seedbank

Introduction

FAR's Weed Research Strategy for the New Zealand Cropping Sector, focuses on a Farming Systems Approach to Weed Management - Non-Chemical Weed Control. In the second of his articles on non-chemical weed control Dr Charles Merfield from The Future Farming Centre, Lincoln, looks at the importance of managing weed seed rain and the resulting seedbank.

While one year's seeding equals seven year's weeding is more metaphorical than technically accurate, the message underlying this old farming adage is of increasing importance as herbicide options reduce.

Key points

- Annual weeds don't just appear out of nowhere - they originate from the weed seedbank.
- Minimising the weed seedbank by minimising the weed seed rain can effectively manage weed populations.
- An increasing number of seed rain management tools are available for use pre- and post-harvest.
- There is considerable potential for easy gains from existing weed seed rain management techniques.
- Research and development is required to expand and improve current technology.

The weed seedbank is the heart of the annual weed problem

After more than half a century of widespread herbicide use it is difficult to appreciate just how revolutionary herbicides were, and how radically they have changed the way farmers and growers think about, and implement weed management – focussing almost completely on killing all weed seedlings and plants growing in the crop. However, the weed plant is only one, often very ephemeral, part of annual and biennial weed lifecycles. These weeds spend the vast majority of their life cycle as seeds, and the plant is simply a mechanism to make more seeds, as quickly as possible. The evolutionary strategy of these plants is simple: be a seed! So controlling the return of weed seeds to the soil (weed seed rain), is a critical, and potentially highly effective, non-chemical means of controlling weed populations.

Big seedbanks = big weed populations

While obvious in hindsight, research shows a 1:1 correlation between the size of the weed seedbank and the number of weeds that emerge in the crop. So, a big seedbank means a lot of in-crop weeds which means a lot of in-crop weeding, and *vice versa*, small seedbanks mean few in-crop weeds, so much less in-crop weed management is needed. Where in-crop weeding is very effective, such as with herbicide use, this is not such a problem, but where in-crop weeding is difficult, expensive, or only kills a lower percentage of weed plants, then a small weed population can be the difference between crop success and failure.

Longevity vs. persistence

Research has shown that weed seeds can survive for decades or even centuries. However, a lot of this research is not representative of real world conditions: for example it may be based on seeds that were collected at the optimum time and carefully stored. Weed seeds in soil face a number of challenges: their nutrients and energy provide a food source for everything from microbes to mice, and soil conditions are often hostile: abrasive and alternating between hot and cold, wet and dry. These and many other factors mean that a seed's theoretical longevity is generally many times higher than its actual persistence in the soil.

Seven years is, in many cases, rather optimistic: in some situations predation means that the vast majority of the weed seed rain is lost within a few weeks or months of harvest. This is especially true of many grasses, the seeds of which only persist for five or six years at most (broad leaf weed (dicot) seeds can survive for much longer). Seedbanks will decline quite quickly on their own if the seed rain is stopped, and very quickly under a deliberate strategy, for example the use of false seedbeds (where weeds are encouraged to germinate, then cultivated before sowing) or fallow.

Nonetheless, a tiny percentage of weed seeds do survive for many years, decades even. These are the ones that appear after long term pasture is turned over, and, if allowed to grow and seed, can quickly fill a field with weed plants in a couple of years, hence, seven years weeding.

Dispersal

Another common misconception is that lots of new weed seeds come in from outside sources. This again has its origins in science, which has categorised the many ways plants have evolved to disperse their seeds and the extraordinary distances that seed can travel. However, while weed seeds can disperse over very large distances, the reality is that most of them don't disperse very far at all. Even weeds like thistles, with highly effective dispersal mechanisms, drop the majority of their seed within a few meters of the parent plant. This means that most weeds grow where their distant ancestors grew, with the only link in this chain of succession from past to present being the seedbank. Two important caveats are: (1) that farm machinery, mainly headers and other harvest equipment can disperse seed widely within fields, and (2) the tiny percentage of seed that is dispersed longer distances is important in spreading weeds to new areas.

Putting it together

The number of annual and biennial weeds in a field is almost entirely due to the immediate past management of that field, especially management of the weed seed rain. Therefore, killing weed plants growing in the crop is not the only way of managing weeds, in either the short or long term. Managing weed seed rain can be as, and sometimes dramatically more, effective, than killing in-crop weed plants with herbicides.

Weed seed rain and seed bank management

There are a wide number of approaches to managing the weed seed rain and therefore the weed seedbank.

Post-header seed destruction

Australian arable farmers, especially those in Western Australia, have significant problems with herbicide resistance. Scientists investigating this problem have found that most of the seeds of resistant weeds such as ryegrass (*Lolium rigidum*), wild radish (*Raphanus raphanistrum*), wild oats (*Avena spp.*) and brome grass (*Bromus spp.*) go straight through the header and rain back onto the ground, replenishing the weed seed bank. Their research has also shown that where these seeds were prevented from returning to the field after passing through the header, dramatic reductions of in-crop weed numbers were achieved. For example, in-crop annual ryegrass emergence was reduced by 90% in just four years (Newman, 2009). Because the methods they used in the research programme (eg chaff carts) were not viable at field scale, a cage mill system that is towed behind the header was developed. This machine, called the Harrington seed destructor, kills about 95 to 100% of weed seeds (depending on species) and can process the chaff in real time. This means that controlling the weed seed rain is now a practical option and is set to play an increasing role in overall weed management in Australian arable systems (Walsh *et al*., 2012). www.ahri.uwa.edu.au/Research/Grains-Research-and-Development-Corporation-projects/Harrington-Seed-Destructor. It should be emphasised that this technology has not been used on the straw loads experienced in New Zealand crops, where yields are much higher.

Figure 1. *The 'Harrington Seed Destructor' in operation behind a header. Photo courtesy of Associate Prof Michael Walsh, The University of Western Australia.*

Spray topping
Researchers in the USA have used growth regulator herbicides to nearly eliminate seed production in hard to control invasive grasses. Applied at late growth stages, when the plants are developing their reproductive parts, these types of herbicides don't kill the plants, but do reduce seed production. This reduction, coupled with the short life of grass seeds in weed seed banks, provides considerable potential for grass weed control in following seasons (Rinella *et al*, 2010).

This method, known as spray-topping, allows American farmers to use different herbicides than those normally used for grass weed control, and has associated benefits for managing resistance and reducing costs. Spray topping is also used in other countries, particularly Australia (Peltzer & Newman, 2009).

Mechanical topping
In the UK, mechanical topping equipment has been developed as a chemical-free alternative to spray-topping. The first machine on the market, and the most well-known, is the Weed Surfer, a very light-weight mower, between 6.5 and 9 meters wide, with many small topper type blades, similar to those under a domestic ride-on mower. Its light weight means it can be held just above crop height on the three point linkage, allowing it to cut, and to some extent, mulch, weed flowers and seed heads standing above the crop. There are a number of videos on the web, just search for "weed surfer".

Figure 2. *The 'Weed Surfer' photo courtesy of CTM Harpley Engineering Ltd.*

The Weed Surfer was originally developed to manage wild oats (*Avena fatua*), a grass weed species with a short lived seedbank, which can be completely eliminated from a site by preventing seed rain for 3-7 years. Similar machines are now being used in a wide range of arable crops for managing charlock (*Sinapis arvensis*), black grass (*Alopecurus myosuroides*), field poppy (*Papaver rhoeas*) and other weeds that hold their flowers and/or immature seed heads above the crop.

The key issue with mechanical topping, compared with spray topping, is timing - many weeds seeds are viable long before they are ripe, so there may be only a short time window between the weeds flowering and the seeds becoming viable when topping will be effective. The later topping is carried out, the more of the cut seeds will be viable (although unripe seeds are often less able to survive long term). Topping too early can also be counterproductive: Mechanical topping relies on the change from vegetative to reproductive growth to be fully effective, so if the weed is topped before it has fully switched to reproductive growth, it may simply regrow and make new flowers. Only when a weed has fully switched to flowering, will it not regrow after topping, and die without producing seed.

Mechanical topping is proving popular with farmers who recognise its immediate and longer term benefits, and research has shown topping to be very valuable, especially when combined into an integrated strategy with techniques such false seedbeds and increased sowing rates. Such combined approaches can be considerably more effective than the standard approach of just spraying in-crop weed plants (Jones & Medd, 2005) and can even eliminate the need for in-crop herbicide use. However, more research is required to confirm the best time for topping and the effect of topping on in-crop weeds in subsequent years. A variation on topping that could be useful in mixed farming enterprises, is cutting weedy areas of the paddock for forage before seed set occurs.

Stubble management

Established approaches such as stubble burning have long been recognised by farmers for their potential to control weeds, especially grasses. FAR trials, conducted as part of the non-inversion agronomy project (2003 – 2008), illustrated that burning cereal crop residues played a key role in brome control for the following crop (Table. 1).

Table 1. *Influence of burning on grass weed control in barley (assessed as plants/m^2, 15 March and 29 April)[1] and seed head numbers/m^2 (5 January)[2]. (F. Dastgheib & N. Poole 2005 – NZ Plant Protection Proceedings 2010).*

	Ripgut brome			Soft brome		
Treatment	15 March	29 April	5 January	15 March	29 April	5 January
Burning	4.5	12.0	0.1	6.0	45.7	0.1
Early Till	44.8	40.2	0.5	29.8	35.0	0.1
Late Till	36.5	0.0	0.5	148.9	1.7	0.1
No Till	40.4	15.5	9.0	209.5	42.2	7.8
LSD 0.05	29.0	21.5	3.7	93.6	ns	3.2

[1] Average of eight 0.1 m^2- quadrats per plot.
[2] Average of six readings of 1 m^2 quadrats per plots.
Notes: Late till treatment cultivated 11 April.
Notes: All treatments glyphosate treated after March assessment and April assessment.
All treatments received uniform application of in-crop herbicides following treatments outlined, crop sown 7 June.

Weed seed rain management is an area for further research and also innovation, both by scientists and farmers, for example, the Harrington Seed Destructor was invented by a Western Australian arable farmer Ray Harrington.

Conclusions

It was a wise farmer who first noted that 'one year's seeding is seven year's weeding'. A growing body of research and practical experience now shows that managing the weed seed rain, and therefore the weed seedbank, through techniques such as post-harvest seed destruction, and pre-harvest spray and mechanical topping, can be just as, or even more, effective for long term weed management than just spraying in-crop weed plants. While to date, much of this work has focused on herbicide resistant weeds, it is just as viable a technique for herbicide susceptible weeds, as a cost effective component of integrated weed management, as an alternative to herbicides, and as a means of preventing herbicide resistance developing in the first place.

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