



## Non-chemical weed management Stale and false seed beds

### Introduction

FAR's Weed Research Strategy for the New Zealand Cropping Sector, focuses on a Farming Systems Approach to Weed Management. In the third of his articles on non-chemical weed control Dr Charles Merfield from The Future Farming Centre, Lincoln, looks at the science underpinning stale and false seedbeds and how to make the most of them on-farm.

The concept of stale and false seedbeds have been around for a very long time, but farmers became less reliant on them with the advent of herbicides. However, they are now a resurgent tool for weed management, often providing simple, effective and low cost weed control. The key difference between the use of these techniques historically and today, is that we now have a scientific understanding of how and why they work, and can use them in conjunction with other management methods.

### The science of weed seeds

There are three key concepts underpinning false and stale seedbeds: dormancy, germination and maximum emergence depth.

#### Dormancy

Weed seeds can sit in the soil for years, even decades, doing nothing, then when conditions are right, they can rapidly jump into life. This ability is governed by dormancy. While the general concept of dormancy is well understood, scientifically our understanding is still developing because the processes that drive it are so complex. The key components of dormancy are illustrated in Figure 1.

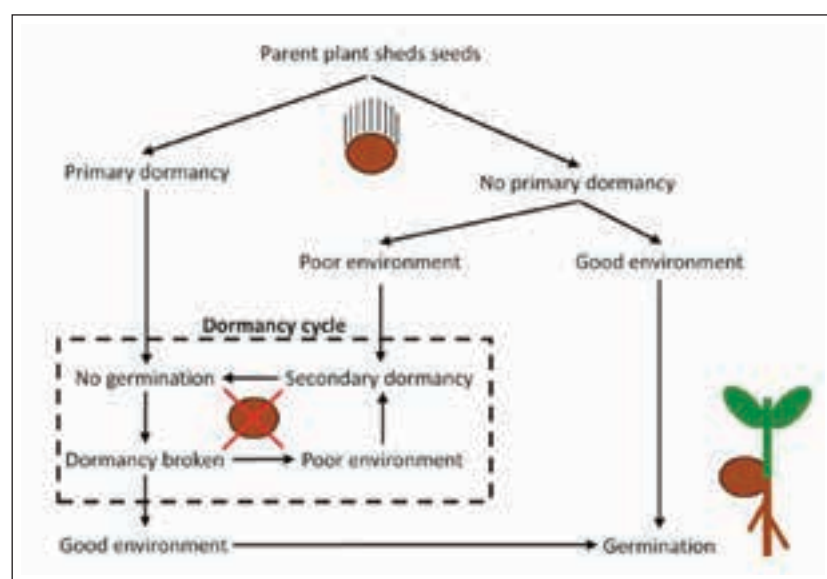


Figure 1. Dormancy mechanisms.

Seeds are shed from the parent plant either with, or without, primary dormancy. Primary dormancy means the seed is dormant when it is shed and will immediately enter the weed seedbank. Conversely, if seeds lack primary dormancy, then two things can happen: (1) under good conditions they will germinate rapidly, (2) under poor conditions, they won't germinate, and will typically enter secondary dormancy and join the weed seedbank.

### Key points

- False seedbeds allow for removal of weed seedlings by shallow cultivation before the crop is sown.
- Stale seedbeds allow for removal of weed seedlings before crop emergence.
- False seed beds can be used after harvest to remove crop volunteers.
- False and stale seed beds can be used before sowing to combat the spring weed flush.
- Most of the weed seed bank is dormant, but the small fraction that is not, will rapidly germinate, given the right conditions.
- Cultivation can create the ideal environment for weed seed germination.
- The vast majority of weeds emerge from seeds within 5 cm of the soil surface.

Seeds with either primary or secondary dormancy enter the dormancy cycle (Figure 1). Seeds cycle in and out of dormancy, driven mostly by internal control mechanisms. When a seed is dormant it is incapable of germinating, even in optimum conditions. The seed will only emerge when dormancy is broken and the seed finds good germinating conditions. If dormancy breaks, but conditions are poor, then germination won't start, and the seed is likely to re-enter dormancy. This means that about 90% ( $\pm 5\%$ ) of weed seeds are dormant and cannot germinate, no matter how good the conditions are. This is why the weed seed bank is so persistent, and why weed seeds are often very difficult to germinate deliberately, much to the frustration of weed scientists. In comparison, many crop plants have no dormancy (either primary or secondary) because, even if their wild ancestor did have it, it has been bred out of them.

Dormancy is not an on or off condition, it is a continuum. Seeds can be partially dormant. Partly dormant seeds will only germinate when conditions are ideal, while if they were fully non-dormant, they would germinate even in marginal conditions. The time spans over which seeds cycle in and out of dormancy vary from weeks to years and are mostly driven by genetic factors.

### Germination

Unlike the dormancy continuum, germination is a yes or no option, there is no means of 'un-germinating', so it is make or break for the seed. Seeds have an impressive range of means of determining if conditions are conducive for them to grow and thrive once they have emerged: the right temperature, moisture, oxygen, nutrients (especially nitrogen) and sometimes light. Through monitoring all these conditions seeds are able to sense how deeply they are buried in the soil. Factors such as low oxygen, low temperature, little diurnal temperature variation and no light, all signal that the seed is buried deeper in the soil. This is a key piece of information for a seed, because if it tries to germinate from too deep within the soil it will die.

### Emergence depth

The maximum emergence depth for seeds is completely constrained by physics i.e. the amount of food and energy that a seed contains exactly determines how much soil a seedling can push up through before it dies of starvation. Most arable weeds can only emerge from a maximum depth of five centimetres. The majority of weedlings that successfully emerge come from seeds in the top three centimeters, and this is the case even for larger seeded species, such as the *Polygonum*'s (knotweeds, wireweed, etc).

## Putting dormancy and emergence depth together on farm

What the above science tells us is that there are three key facts to understanding weed emergence:

- Most (90%) of the weed seed bank is dormant, but the small fraction that is not, will germinate rapidly under the right conditions.
- Cultivation can create an ideal environment for weed seed germination.
- The vast majority of weeds will have emerged from seeds within a few centimetres of the soil surface.

These three simple facts are the foundation on which stale and false seedbeds are built.

### Stale and false seedbeds

Often the terms stale and false seedbeds are used interchangeably, but in fact they define two related but different techniques. False seedbeds are so-called because the first seedbed is not the true seedbed as it is destroyed by re-cultivation while stale seedbeds are so-called because the seedbed is no longer freshly cultivated at the time of crop planting/sowing, rather it has aged or become stale by planting time.

#### Stale seedbed

Figure 2 shows the principle of a stale seedbed. The seedbed is prepared (a), weed seeds in top 5 cm of soil germinate (b-c), crop is sown (d), weed seedlings emerge (c-e), weed seedlings are killed (f), immediately prior to crop emergence (g). For non-chemical weeding a thermal weeder, e.g. flame or steam is used to kill the weeds, otherwise a broad-spectrum herbicide would be used.

The key advantage of the stale seedbed is that the weeds are killed without any soil disturbance, so the potential for bringing up new seeds, or for the germination requirements, (oxygen, temperature, light etc) to be increased is effectively zero. Stale seedbeds should therefore result in lower levels of weeds in the following crop. However, there are times when a new germination stimulus is wanted, e.g. to aggressively flush out weed seeds, so stale seedbeds are not always the best option.

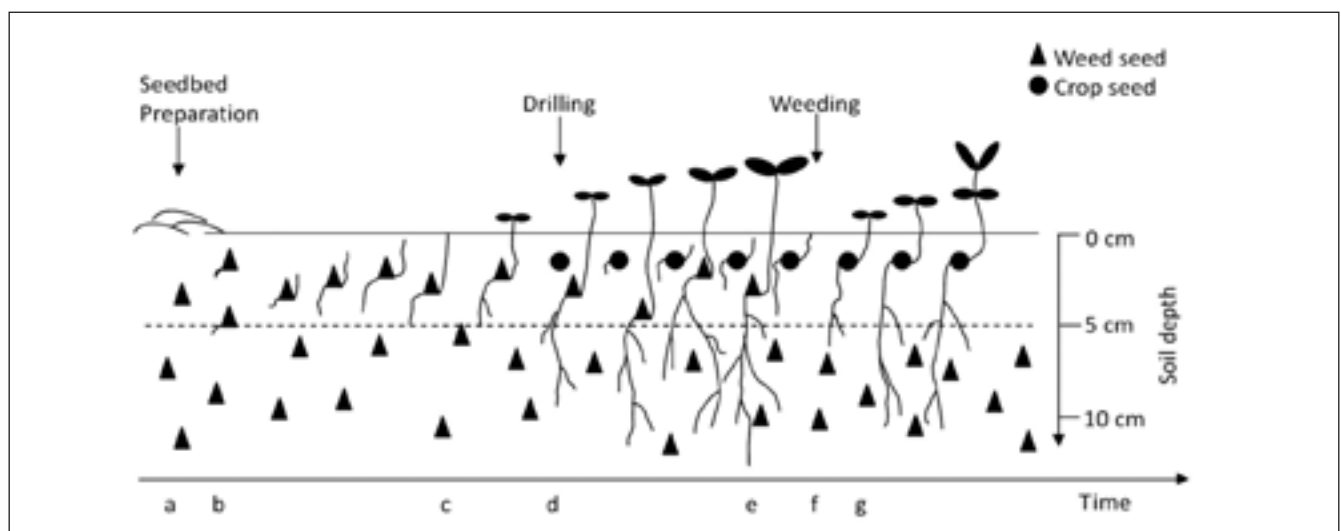
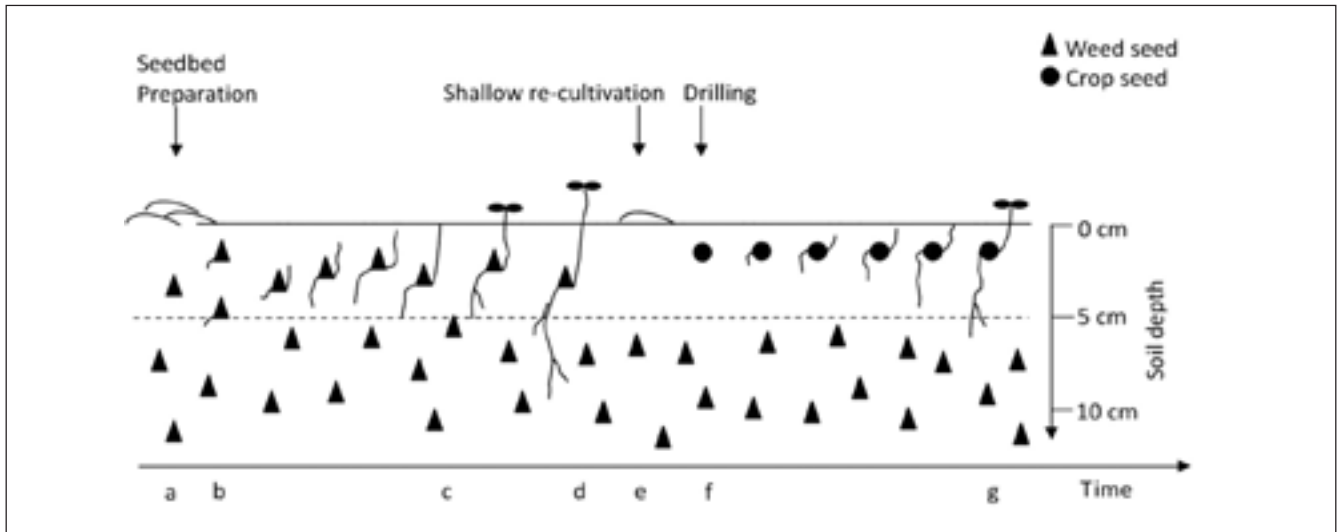


Figure 2. Illustrative scheme of a stale seedbed.

### False seedbed

Figure 3 shows how a false seedbed works. The seedbed is prepared the same as for a stale seedbed (a), weed seeds in top 5 cm of soil germinate (b-c) and then emerge (c-d), the soil is then re-cultivated with the minimum disturbance necessary to kill weed seedlings(e), the crop is then sown (f) germinates and emerges (g).



**Figure 3.** Illustrative scheme of a false seedbed.

The key to false seedbeds is that recultivation must be as shallow as possible, i.e., within the 5 cm and ideally 3 cm depth from which most weeds emerge. If cultivation is deeper than this, then it will bring up non-dormant but ungerminated seeds from below the emergence layer, which will emerge in the crop, reducing the effectiveness of the technique. The deeper the recultivation, the more new weed seeds it will bring up, and at some point, say around 10 cm depth, the entire effect of the false seedbed is lost.

### Equipment

As noted above, the re-cultivation depth is critical to the success of false seed beds. It must be less than 5 cm deep and kill 100% of emerged weeds. This need for shallowness and 100% weedling kill is beyond the ability of many common cultivators. Harrows and stubble cultivators can do an adequate job, but they tend to go deeper than ideal and/or fail to achieve sufficient weed kill. Where false seedbeds are being used as a regular component of weed management, and/or they are being used in critical situations, e.g. before vegetable seed crops, then using more specialist machines can pay considerable dividends.

In terms of off-the-shelf gear, spring-tine-harrows are a leading tool (see Arable Extra 97), with the benefit that they have a wide range of other uses on-farm. However, even when used aggressively, they may not achieve 100% weed kill, and more than one pass may be required. Incomplete weed kill need not be a problem in competitive crops such as cereals, but in less competitive crops, such as vegetable seeds, it won't be enough. Where 100% weed kill and very shallow cultivation is essential, there are two main approaches: 1) horizontal rotating rods, that have evolved from American rod-weeders, or 2), gangs of flat, A-blade sweeps, typically used on interrow hoes. Figure 4 shows an original rod weeder from the USA, a rod incorporated into an S tine cultivator, and an A blade sweep cultivator.



**Figure 4.** American rod weeder (left), false seedbed cultivator using rod weeder (middle), A-blade sweeps (right).

For stale seedbeds either flame or steam weeders may be used for non-chemical approaches. These technologies provide control equivalent to a contact herbicide, not a systemic one, so they are most effective against small weeds and dicots.

Regardless of whether a false or stale seedbed is used, or the type of machinery, if the seedbed is not in optimum condition, e.g. too dry or cloddy, then germination will be reduced, and weeds are then likely to emerge later in the crop. Therefore, the golden rule is that the original seedbed must be of the best quality possible, and if conditions are dry and irrigation is available, then the soil should be moistened.

## When to use false and stale seedbeds

### Harvest

One of the main uses for false seedbeds is at harvest to manage weed seeds shed in the crop and also volunteer seed crops, e.g. oil seed rape. In terms of volunteers, as noted above, most crops don't have dormancy, so, if they find good germination conditions after release from the parent plant, they will germinate readily. A very shallow cultivation, e.g. via harrowing, and/or rolling, after harvest can trigger germination and the seedlings can then be killed with further shallow cultivation or herbicide. Conversely, if the seed is cultivated into the soil (buried), especially by ploughing, then it will not germinate, and if it has some dormancy capability, is likely to enter the seed bank and become dormant. Therefore, using a false seedbed at harvest can all but eliminate recently shed crop seeds, while ploughing them under can result in volunteers coming up for many years.

An important difference to note between the grasses / monocots and dicots (both weeds and crops) is that grasses generally have short lived seeds, while many dicots, especially those with hard seed coats, have potentially long lived seeds. Ploughing grass seeds under and then not re-inverting the soil for several years, will result in the majority of seeds dying, this is a well established technique for grass weed management. Doing the same for dicots generally does not result in the same level of seed death, so these seeds will return to the surface in a viable state with future cultivations.

### Sowing

The other main use of false and stale seedbeds is prior to sowing, especially in the spring, to help combat the spring weed flush. Figure 5 shows crops of direct-drilled carrots and silverbeet which have received mechanical inter-row weeding rather than herbicides. The high level of intra-row weed control is due to false and stale seedbeds. Specialist false seedbed cultivators are essential to achieve such high levels of weed control.



**Figure 5.** High levels of weed control achieved using false and stale seedbeds in direct-drilled ware carrots and silverbeet. The fat hen plant in the left photo was the only one in 200 m of bed.

## Conclusions

False and stale seedbeds can be a highly effective and often inexpensive means of reducing the non-dormant weed seedbanks in the emergence zone. The weeds that could have infested the crop are grown and killed before, or as part of, crop establishment. When used as part of a whole-system approach to weed management, false and stale seedbeds can achieve very high levels of weed control, allowing subsequent weeding operations, both chemical and non-chemical, to be more effective, easier and often cheaper.

## References

Merfield, C. N. (2013). *Non-chemical weed management - mechanical weeding*. Christchurch: Foundation for Arable Research (FAR). [www.far.org.nz/mm\\_uploads/X97\\_Non-chem\\_weed\\_mgmt\\_-\\_mechanical\\_weeding.pdf](http://www.far.org.nz/mm_uploads/X97_Non-chem_weed_mgmt_-_mechanical_weeding.pdf)

©This publication is copyright to the Foundation for Arable Research and may not be reproduced or copied in any form whatsoever without their written permission.

This Arable Extra is intended to provide accurate and adequate information relating to the subject matters contained in it. It has been prepared and made available to all persons and entities strictly on the basis that FAR, its researchers and authors are fully excluded from any liability for damages arising out of any reliance in part or in full upon any of the information for any purpose. No endorsement of named products is intended nor is any criticism of other alternative, but unnamed product.