

Effective Integrated Weed Management - Case Study

Managing weed seed banks through stale seed beds and inter-row cultivation

Schreurs & Sons, Clyde, Victoria



**INTEGRATED WEED
MANAGEMENT**

**Hort
Innovation**
Strategic levy investment

**VEGETABLE
FUND**

UNE
University of
New England

Summary

Grower

Adam Schreurs, *Schreurs & Sons*.

Location

Clyde and Devon Meadows, Cranbourne district, Victoria.

Rainfall

Approximately 750 mm annual average.

Soil type

Sandy.

Crops produced

Celery, leek, spinach, rocket, snow pea tendrils.

Major weeds

Common groundsel (*Senecio vulgaris*), mallow (*Malva parviflora*), dwarf nettle (*Urtica urens*), oxalis (*Oxalis* spp.), shepherd's purse (*Capsella bursa-pastoris*), chickweed (*Stellaria media*), wireweed (*Polygonum aviculare*), nutgrass (*Cyperus* spp.).

Integrated weed management strategy

- Post-harvest non-selective herbicide.
- Bed forming cultivation.
- Stale seed bed with multiple weed controls.
- Pre-emergent and/or post-emergent selective herbicide.
- Inter-row cultivation.
- Hand weeding of remaining weeds.

Key benefits

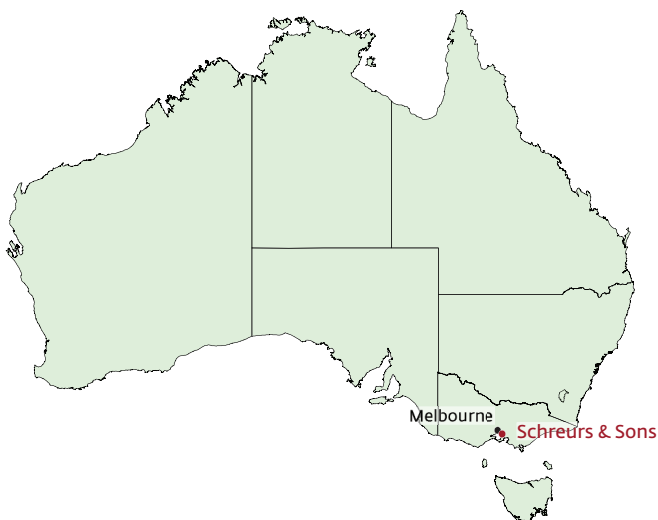
- Gradually reducing the weed seed bank over time, especially of potentially herbicide-resistant weeds.
- Reducing reliance on herbicides, and improving capacity to use herbicides more strategically.
- Minimising weed germination and competition within the crop.
- Reducing weed management costs (especially cultivation and hand weeding) over time.
- Improving soil health through reduced usage of deep cultivation.

Introduction

History

The Schreurs family have been growing vegetables in the Cranbourne district, approximately 50 km south-east of Melbourne, since the 1950s. Originally renowned for introducing Dutch carrots into the Australian market, Schreurs & Sons has now diversified into growing a variety of vegetable crops.

Today, Schreurs & Sons own five farms in the outer Melbourne suburbs of Clyde and Devon Meadows, totalling approximately 550 hectares. Across these farms, approximately 400 hectares are dedicated to vegetable production. The business employs about 180 staff, rotating across the five farm sites depending on need for ground preparation, planting and sowing, crop management, and harvest activities.



Map 1 Location of Schreurs & Sons, Cranbourne district, Victoria.

Adam Schreurs is one of several third-generation members of the family to remain involved in the business, and operates the business alongside his cousins Christopher and Ben Schreurs. Adam has been involved in the vegetable industry his whole working life, and his son is now becoming involved in the family business.

Crops

Today, Schreurs & Sons' most significant crop is celery, with approximately 20,000 tonnes grown each year. Other important crops include leek (Figure 1), spinach, rocket, and snow pea tendrils. Crops are grown intensively year-round, with a winter fallow period.



Figure 1 Planting a leek crop.

Farm characteristics

In this case study, we focus on Schreurs & Sons farm at Fisheries Road, Clyde. This farm was purchased by the Schreurs family in 2000, and today Adam acts as farm manager at this site, in addition to his business-wide responsibilities.

The site was formerly a dairy farm, and the initial weed burden faced by Schreurs & Sons reflected this land use history, including a large grass weed seed bank, as well as capeweed (*Arctotheca calendula*) and clover (*Trifolium* spp.). Over time, this weed seed bank gradually gave way to heavily-seeding annual broadleaf species, favoured by a vegetable production system.

This particular farm features sandy soil, receives an average annual rainfall of approximately 750 mm, and is 100% dedicated to vegetable production.

Former weed management approach

Weed management methods

Until the late 2000s, the weed management strategy used by Schreurs & Sons relied heavily on the following.

- *Regular and relatively deep cultivation passes*, employed post-harvest and during the fallow period to restrict weed growth before the next crop was planted.
- A range of *pre-plant and post-plant selective herbicides* registered for use within their various vegetable crops.
- In some crops, relatively few herbicide options were available, particularly post-emergence.
- *Hand weeding* was used to follow up on surviving weeds.
- *Chemical fumigation* (using metham sodium) was used with considerable success, particularly to reduce the dwarf nettle seed bank, and minimise its impact in rocket crops.

Why did they decide to change?

Reduced herbicide effectiveness

Adam and his team became concerned about reduced effectiveness of the relatively limited range of selective herbicides available to them. Some weeds commonly found on one of their farms, notably common groundsel, seemed to be developing resistance to the herbicides on which the business had heavily relied.

More strategic reliance on herbicides

Schreurs & Sons considered that it would be more effective to be able to utilise the selective herbicides available to them more strategically. This may involve integrating a greater variety of weed management techniques across the crop, post-harvest and fallow periods of the crop cycle, and moving away from a regular 'calendar spraying' approach to more flexible and responsive herbicide use.

A return to previous approaches

Prior to the emergence of the various herbicides which initially made growing most of their crops much easier, Schreurs & Sons had relied quite heavily on cultivation and bed management before, within and after their vegetable crops to help keep on top of weeds. Knowledge of these techniques remained in the family, and the reduced effectiveness of their herbicide options provided an opportunity to shift back to a similar approach.

A desire to reduce costs

As herbicides were becoming less effective, the team observed that cultivation and especially hand weeding costs were increasing. Diversifying the weed control methods used had the potential to reduce these costs over time, particularly if they led to reductions in the weed seed bank and therefore less weeds emerging in the crop.

A desire to improve soil health

Reducing the number of relatively deep cultivation passes during the winter fallow period was also an attractive option to Adam and his team. Their goal was to maintain and improve soil health and structure through a reduced till system, while not compromising the effectiveness of their strategy.

Concerns regarding chemical fumigation

In response to human, animal and soil health concerns regarding chemical fumigation, Adam preferred to move away from this practice.

Growing interest in organic production

Schreurs & Sons are interested in shifting at least some of their land into organic celery production in the longer-term. Looking at ways to reduce the business' reliance on herbicide therefore provided an opportunity to determine how effective alternative techniques may be.

New weed management approach

Since the late 2000s, Schreurs & Sons have grown to rely more heavily on stale seed beds and inter-row cultivation as options for reducing their reliance on regular herbicide application, and potentially reducing the cost of other weed management activities such as hand weeding. Subsequently, both methods have also become increasingly important in compensating for reduced herbicide effectiveness noted on the farm.

This Integrated Weed Management (IWM) strategy suits the large scale of Schreurs & Sons production system, which features a winter fallow period between crops. This period is long enough for multiple cohorts of weeds to germinate and be controlled in the formed beds using the stale seed bed technique, before the next crop is sown or planted.

Inter-row cultivation suits many of the crops produced by Schreurs & Sons, which are grown in rows along the crop beds.

Schreurs & Sons continue to rely on several other weed control methods as part of their overall IWM strategy. Each of the key components of this strategy is summarised below.

Cultivation to form crop beds ✓ ✓

Bed preparation cultivation employed by Schreurs & Sons usually involves a single pass using a chisel plough

to a depth of 300 mm, followed by two passes with a bed former.

Stale seed bed ✓ ✓

A *stale seed bed* involves preparing the crop beds well before the crop is planted. Several cohorts of weeds are allowed to germinate in the beds, and controlled early each time using the broad-spectrum herbicide glyphosate (Figure 2). Shallow tillage of the crop beds may be used in place of broad-spectrum herbicide to control recently germinated weeds in an organic production system.

Schreurs & Sons implement a stale seed bed once each season. From approximately early June, the raised beds for the next crop are formed, and then for about the next six weeks the stale seed bed is in place until the next cash crop is planted.

Usually, the seed bed is irrigated once to encourage a flush of weed germination. Glyphosate is applied to the beds approximately four weeks after the bed has been formed, to control any weeds that have emerged. Additional weed flushes are controlled if time permits. The crop is then planted into the clean beds. Soil disturbance is minimised during planting to limit further weed germination.

Occasionally, the team may implement a shallow cultivation of the crop beds to control weeds rather than using glyphosate. However, this is usually not desirable for Adam as he believes it can open up the top 'crust' of soil and allow soil temperatures to decline. It may also

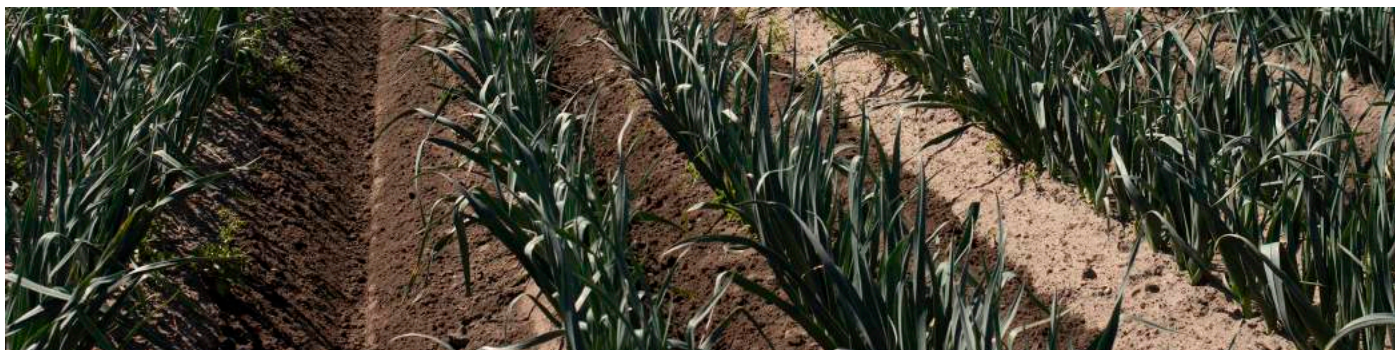
encourage an additional cohort of weeds to germinate. This is not a problem if there is then time to cultivate or spray the additional cohort of weeds. However where the fallow period is relatively short, it can create a weed burden in the following crop.

The length of time a stale seed bed approach can be used by Schreurs & Sons is usually restricted by the amount of land available to about six weeks. Ideally, Adam would like to use longer-running stale seed beds, using a mixture of glyphosate application and shallow cultivation to germinate and control multiple weed cohorts. This may be feasible in other vegetable crops, and may be helpful where weed seed bank levels are very high (e.g. newly used fields).



Figure 2 A stale seed bed, ready for crop planting.

Inter-row cultivation ✓✓



Inter-row cultivation involves one or more shallow passes in a growing crop, to till the rows between the crops on top of the raised crop bed, and/or in the wheel tracks. Some benefits may be achieved within the crop row itself as well, where inter-row cultivation implements may provide some 'hilling' of the soil, potentially covering and suppressing recently germinated small weeds.

Schreurs & Sons have two implements available to them to carry out inter-row cultivation.

- A 'Weedfix' cultivator using rotating tines (Figure 3).
- A customised cultivator, fitted with Dutch hoes and knives that has been set up specifically to suit the bed and row spacing used on the farm (Figure 4).

Both implements allow cultivation of the crop bed between the rows of crop plants, as well as on the sloped sides of the raised beds. Shallow inter-row cultivation is also completed within the wheel tracks by Adam and his team, using the customised cultivator.

The team usually uses inter-row cultivation twice, at least four weeks prior to harvest, and generally to a depth of 30 to 40 mm.

The Weedfix cultivator is used within less mature crops, and the customised cultivator is used within more mature crops. The relatively mature crops are able to withstand the more significant soil movement that occurs when using the customised cultivator.

GPS technology is not required to complete the cultivation passes. Experienced staff are able to complete each pass by eye at relatively high speed, using crop bed lines and irrigation risers as reference points.

Amongst the crops grown on the farm, celery and leeks are particularly suited to inter-row cultivation because of their relatively upright form. However, inter-row cultivation is used to varying degrees within all crops grown by the business.



Figure 3 A 'Weedfix' inter-row cultivator, used on the farm in less mature leek crops for shallow cultivation within the crop bed.



Figure 4 A customised inter-row cultivator, set up to the specific bed and row spacing used on the farm. The cultivator is being used within a more mature leek crop to cultivate within the crop bed as well as the wheel tracks.

Herbicide

Herbicides remain a critical component of his team's IWM strategy, although Adam believes that herbicides have become less effective in managing key weeds on the farm such as common groundsel.

Herbicides are usually used at rates towards the lower end of the recommended scale, to minimise the risk of damage to the crop. However if a heavy weed burden is observed, the application rate may be increased somewhat.

When are herbicides used in the crop?

Herbicides are used at various stages in the crop life cycle to manage weeds.

Pre-plant herbicides are regularly used where they are registered for the crop grown, primarily to manage broadleaf (dicot) weeds. Depending on the crop, these may be applied at the time of transplant, or a few days later providing each application adheres to label requirements and will not cause any damage to the crop. In some crops, more than one pre-plant herbicide may be used, with the second or subsequent products used in part to manage a wider range of weeds that may survive if only one pre-plant herbicide application was used.

Post-plant herbicides are often applied once within the crops, generally to manage grass (monocot) weed species.

Herbicide options and availability vary across the various crops grown by Schreurs & Sons. For example, multiple selective herbicides are available for use within the celery crop, but none within the snow pea tendril crop.

Rotating between various cash crops allows Adam and the team to employ different herbicide modes of action across growing seasons, allowing them to manage different weeds over time. One of the key benefits of herbicide rotation is in reducing the risk of herbicide resistance developing. When considered alongside the non-herbicide weed control techniques that have become increasingly important to Schreurs & Sons, a key outcome of their IWM strategy is to extend the useful life of the limited herbicides available to use within their crops.

Other herbicide application

The *broad-spectrum* herbicide glyphosate is sometimes applied outside crop periods at the highest registered rate to control nutgrass (*Cyperus* spp.) outbreaks. This is applied at the time of nutgrass flowering to increase the chances of success, by maximising uptake through the actively growing shoots and tubers. However, the level of success can vary considerably, e.g. depending on weather.

Hand weeding

Hand weeding is used to remove weeds that have survived pre-plant and post-plant herbicide application and inter-row tillage. It is less likely to be required in crops such as rocket and spinach which form a relatively thick canopy, compared with other crops produced by Schreurs & Sons such as leeks, which features a relatively upright, open canopy.

A team of 4-5 staff is usually assigned to hand weed, and are accountable for successful removal of weeds in a given area. Usually, hand weeding activity occurs relatively late in the crop. The soil is relatively light and so weeds can be pulled out from the soil easily by hand, without the need for implements such as hoes.

Adam considers hand weeding important in minimising crop contamination, reducing crop processing costs, and in helping to manage the weed seed bank by

complementing weed control implemented at other stages of the crop cycle. Weeds that have produced seed are carried away from the field during hand weeding activity.

While hand weeding makes an important contribution to IWM for Schreurs & Sons, Adam considers it to be a last resort and a sign that the preceding weed management techniques were not as successful as desired. Where possible, hand weeding activity is minimised or avoided altogether, for example where the weed burden is considered to be relatively minor. Nonetheless, weed survivors which have flowered are often removed from the paddock by hand to help deplete the weed seed bank.

Benefits of the new approach

The key principle of the Schreurs & Sons strategy is to *minimise the number of weeds that mature and produce seed – particularly those weed species which they believe have started to show signs of resistance to herbicide.*

No matter what IWM approach is used, this principle is applicable to all vegetable farms.

Weed and farm management and impact

- Adam considers that the most significant benefit of the IWM strategy now employed by Schreurs & Sons has been to gradually reduce the weed seed bank.
- By introducing alternative methods (stale seed beds and inter-row cultivation), the team are successfully compensating for reduced effectiveness of the herbicides available to them, and at the same time reducing their overall reliance on these herbicides.
- Herbicides can be used more strategically, and the risk of herbicide resistance becoming a more significant issue on the farm can be expected to be less significant.
- Reduced tillage during the winter fallow and bed formation has been beneficial for soil health and soil structure.

Financial benefits

Despite initially being slightly more expensive than the former, more herbicide-reliant strategy, the IWM strategy now used by Schreurs & Sons has helped improve overall farm profitability.

- Improved crop yield and quality due to reduced weed competition.
- Reduced processing costs.
- Weed management costs are gradually reducing over time, as the weed seed bank is depleted.

Limitations of the new approach

Some weather conditions and stale seed beds

Stale seed beds are used by Schreurs & Sons during the winter, when vegetable crops are usually not grown. However, using a stale seed bed successfully requires a sufficiently dry paddock to be able to drive the tractor along the crop rows while spraying glyphosate.

If the paddock is wet for an extended period, it may be possible for weeds to establish and produce seed. Adam notes that this is particularly true of common groundsel and dwarf nettle, both of which are capable of germinating, growing and producing seed rapidly.

This means that relying on stale seed beds comes with a risk of replenishing the weed seed bank if paddocks are wet for an extended period.

Timing of inter-row cultivation is critical

Inter-row cultivation has been most effective when it is carried out early in the life of weeds – ideally, when weeds have just reached their first true leaf stage.

Waiting until weeds have had the chance to grow much larger than this can reduce the effectiveness of this method. Because inter-row cultivation utilises shallow tillage, larger weeds may not be removed from the soil.

At the same time, larger weeds that are removed can attach themselves to the tines. This is particularly an issue if the soil is relatively moist at the time of cultivation. Under these conditions, the weed may be dragged through the paddock and re-establish elsewhere. Weeds attached to the tines in moist conditions can also cause more soil to bank up against the crop plants, resulting in dirty produce.

Innovation in IWM

Adam's willingness to innovate and continually explore new approaches, or to re-introduce 'old' approaches which are known to work well if used appropriately, is one of the keys to Schreurs & Sons ongoing success, not only in weed management but across the business.



Figure 5 Adam Schreurs (Schreurs & Sons, left) and Carl Larsen (RM Consulting Group, right).

Before he makes a change, in weed management or elsewhere, Adam considers the economic and environmental pros and cons of the proposed change closely. He seeks advice from family members and others involved in the business, and other vegetable growers who have tried the approaches he is interested in. He also reads widely on innovative approaches, listens to relevant industry podcasts, and attends and hosts field events.

With regards to weed management, Adam remains keen to explore alternative options despite the current success of the IWM strategy in place for Schreurs & Sons. Some of the options that have recently attracted Adam's interest include the following.

- Cover cropping, to suppress weeds during the winter fallow and potentially to reduce the weed seed bank through a biofumigant effect.
- Thermal weed management (steam and/or flame weeding) and microwave weed control technology.
- Using a one-off chemical fumigant application, potentially with a product other than metham sodium, but only if the weed seed bank is observed to have increased significantly and weeds were becoming harder to keep under control using the current IWM strategy.

- Organic knockdown herbicides, which he considers are currently quite costly but are still worth bearing in mind as a future option.

Adam's willingness to support innovation in the vegetable industry is reflected by his willingness to host cover crop research led by the Hort Innovation-funded *Soil Wealth Integrated Crop Protection* project.

Carl Larsen from RM Consulting Group and an Industry Development Officer in Victoria for the Hort Innovation-funded *VegNET* project, considers Adam's continued willingness to innovate will allow Schreurs & Sons to keep their weed burden to a manageable level in the longer term. His approach to innovation is suitable to all vegetable farms.



Figure 6 Soil Wealth Integrated Crop Protection cover crop demonstration site, Schreurs & Sons (source: Carl Larsen).

Conclusion

The experience of Schreurs & Sons suggests that **being willing to try different approaches, use successful strategies diligently, and always being on the lookout for new approaches, will have longer-term benefits.**

Although their new IWM strategy was initially a little more costly and time consuming than the previous one where herbicides were more of a mainstay, Adam and the Schreurs & Sons team are now enjoying the rewards of their willingness to try something different, and to continue to innovate.

We are grateful to Adam Schreurs and the team from Schreurs & Sons for sharing their story of successful Integrated Weed Management, and to Carl Larsen (RM Consulting Group) for his thoughts on innovation in vegetable production.



Disclaimer

Descriptions of herbicide use in this guide are not to be taken as recommendations. Herbicides must only be used in accordance with the recommendations provided on herbicide labels. Readers are reminded that off-label use of herbicides may be restricted or not permitted under relevant legislation. Landholders are therefore advised to determine current registrations and legal requirements for herbicides they may be considering, and to consult with their State or Territory government departments regarding the legal requirements they are obligated to adhere to relating to herbicide use and weed control.

Coleman, M., Kristiansen, P., Fyfe, C., Sindel, B. 2020. Effective Integrated Weed Management - Case Study: Managing weed seed banks through stale seed beds and inter-row cultivation. School of Environmental and Rural Science, University of New England, Armidale.

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