Windrow burning for weed control – WA fad or viable option for the east?

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Take home message

- Continued reliance on herbicides alone is not sustainable in our continuous cropping systems. Rotating herbicides alone will not prevent the development of resistance
- Early implementation of windrow burning will prolong the usefulness of herbicides, not replace them
- Windrow burning is the cheapest non-chemical technique for managing weed seeds present at harvest
- Even with higher summer rainfall, windrow burning is a viable option for NSW cropping systems
- Windrow burning is an effective weed management strategy, even in the absence of resistance
- Growers need to begin experimenting now on small areas to gain the experience needed to successfully implement the strategy

Introduction

Harvest weed seed management is the practice whereby weed seeds present at harvest are treated in some manner so as to prevent their return to the weed seed bank as viable seed that would otherwise be able to proliferate the following season. Windrow burning (WB) is one tool that is implemented in Western Australia from the broader concept of harvest weed seed management. Other techniques include chaff carts, direct baling or, more recently, treatment with the Harrington Seed Destructor (HSD). Walsh (2012) has shown that the effectiveness of these different systems to be similar.

In WA, the practice has been widely adopted, with estimates that 75% of growers are implementing some form of the management concept. An estimated 50% of growers are specifically using WB (Peltzer, 2011). Widespread herbicide resistance, often to multiple herbicide groups, has been driving changes to farming systems and the uptake of such practices.

This paper is about the motivations for putting WB into practice and about addressing some of the key concerns about the practicality of WB in NSW farming systems.

Why use windrow burning?

Many farming systems in central and northern NSW have evolved to be based on continuous cropping and zero tillage. With no grazing of pasture leys or winter fodder crops and no burning or regular cultivation, there is increasing pressure on herbicides, particularly those used in-crop. In many cases, there is total reliance on herbicides for weed control during the growing season and in many cases the whole time.

Concurrently, there has been a reduction in sowing rates and increases in row spacing, resulting in less crop competition for weeds. Coupled with the planting of less competitive crops such as chickpeas and the increased frequency of early sowing through moisture seeking techniques or dry sowings have placed further pressure on in-crop and pre-emergent herbicides.

Rotating herbicides has long been promoted as one of our best tools against the development of resistance. However, established practices, economics and droughts have all contributed to poor implementation of this strategy. Furthermore, it should be noted that rotating herbicide groups will not prevent the development of herbicide resistance but only slow the rate of development. There are many examples across the farming regions of Australia, most notably in WA, where herbicide rotation has not prevented resistance developing. This is unsurprising, given modelling has shown that resistance to Group A and B chemistry can occur after as few as 4 applications (Table 1).

Table 1: Years of application before herbicide resistance develops

Herbicide Group	Years for resistance to develop
B (SU, IMI)	4
A (fops & dims)	6-8
I (phenoxy)	10+
C (triazines)	15+
D (trifluralin, DNA)	15+
L (paraquat, diquat)	15+
M (glyphosate)	12+

Source: Dr. Chris Preston

The value in the zero tillage system and stubble retention is well proven and accepted in central and northern NSW. To return to widespread conventional and multiple cultivations would be too costly, both economically and environmentally, in most circumstances. As an option for managing resistant weeds, with the exception of options such as full cut sowing or mouldboard ploughing, the effectiveness is likely to be limited.

Reintroduction of grazing could be beneficial but enterprise profitability, labour limitations and the decline in infrastructure such as fences, yards and shearing sheds would limit this option in many areas. In livestock systems, there is still the requirement to prevent weed seed set through options such as heavy grazing and hay/silage making which targets seed set.

The use of lower risk herbicides such as glyphosate and paraquat can be of assistance in the pasture phase through the use of spraytopping. However, this places further selection pressure on these groups.

Currently, there are few options for controlling escapes from in-crop herbicide applications. It is the return of these seeds, be it susceptible or resistant biotypes, that drive the cycle of the need for herbicides every year. If these seeds are resistant seeds surviving such applications these are the main driver of resistance development within a paddock. Green and brown manuring have a large opportunity cost in most situations and are likely to be ignored in times of high crop yields and/or grain prices.

Late season control of seed set with herbicide applications with products such as glyphosate, paraquat, diquat, 2,4-D and metsulfuron-methyl are widely used in other states and have registration in some situations in NSW. The main disadvantage of these options is that the hot, dry finishes that typify the end of the cropping season in central and northern NSW tend to result in weeds setting seed before it is safe (from a yield point of view) to apply these herbicides. Wetter, cooler years such as 2010 and 2011 could allow such applications, but this couldn't be considered a regular control option. The other main disadvantage is that it is just another chemical option, placing further pressure on these modes of action.

As the name suggests, harvest weed seed management aims to target any weed seeds that are present at harvest. Any resistant plants that survived earlier herbicide applications will therefore be targeted and the seed removed from the seed bank for the following season. This assists in slowing resistance development and also breaks the weed cycle of susceptible survivors; that is plants that survived herbicide applications due to late emergence, adverse weather conditions, poor application techniques etc. This further reduces the burden placed on herbicides each year.

There are three main non-chemical options for managing weed escapes at harvest. Chaff carts can be used to collect the chaff fraction and dump and burn at a convenient location and time. However, they are another item of plant to purchase (often around $80,000), require more horsepower to operate, create a lot of smoke during burning and can leave bare patches if burnt in the paddock. The HSD is another option, but has a very high capital cost, reportedly in excess of $200,000. It does, however, have the advantage that there is no need to introduce fire to kill weed seeds as they are mechanically destroyed at harvesting. It also means there is no reduction in the amount of trash returning to the paddock.

All the systems require harvesting at lower height than most growers are accustomed to, which could impact upon harvest efficiencies in taller/heavier crops. But with modern larger capacity headers, the impact will be minimised and in more typical crops of our region there may be little or no reduction in harvesting capacity. 15cm is being used as the industry benchmark for the height of the cutter bar. Research (Walsh & Powles, 2012) has suggested that a large majority of seeds from problem weeds can be collected when cut at this height (Table 2).

Table 2: Proportion of total seed production retained above 15cm harvest height

Species	Seed retention above 15cm (%)
Annual ryegrass	88 (77-100)
Wild radish	99 (95-100)
Brome grass	73 (61-95)
Wild oats	85 (73-100)

Source: Walsh & Powles (2012)

WB is the cheapest and easiest to set up which makes it attractive to most growers. It will allow growers to test the concept and check the fit for their farming system. Chaff carts and the Harrington Seed Destructor and the larger investments could be considered after "testing the water" with WB.

Previous trial work by Walsh & Newman (2007) has shown that to achieve the temperatures and fire duration required to kill weed seeds, the trash needs to be dropped into a narrow windrow, rather than just dropped off the sieves. Ryegrass required 10 seconds above 400°C to guarantee death, whilst wild radish needed 500°C for the same period to be killed. Figure 1 shows that to achieve these temperatures and durations, narrow windrows are much more effective than standing stubble or conventional windrows. The duration of heat intensity in a narrow windrow implies this technique will be effective against most weeds. The work also calculated that less than 10% of the field is exposed to erosion when utilising this technique.

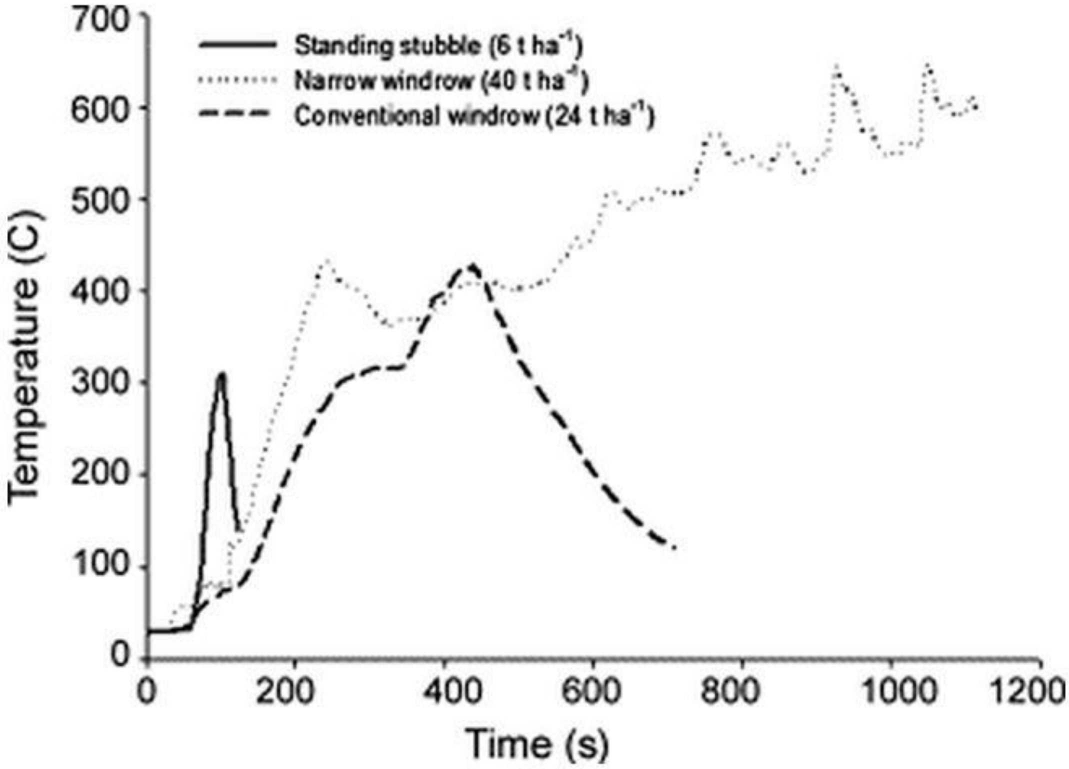

Figure 1: Temperature in burning stubble

Source: Walsh & Newman (2007)

The local grower experience – Maurie Street

The need to change and take a new approach was driven home following a recent trip to WA. For some WA growers, there are no longer any effective in crop herbicide options for ryegrass. Clethodim resistance is not uncommon and Group A and B herbicides failed a number of seasons ago in many areas. Growers are left with only a small suite of pre-emergent chemicals left at their disposal; namely trifluralin, Boxer Gold® and Sakura®. There is further concern with wild radish resistance to Group I chemistry and widespread diflufenican, Group C and B resistance.

Despite these odds that may seem insurmountable to those of us at the early stages of managing resistance, many WA growers continue to farm successfully, with surprisingly clean crops. This is largely due to harvest weed seed management.

My motivation for change was clear; if I did not want to be where WA is today in 5 years' time, I had to do something different. The question was would WB work for us as it does in WA?

Some of the key concerns for me were-

1. How do you burn higher yielding crops (>2t/ha) without the whole paddock burning? The perception is that average WA yields can be much lower than ours, resulting in smaller stubbles and so easier to contain the fire
2. What about our summer rainfall? Is this going to reduce the effectiveness of the burn? Will the windrows get too wet to burn, or compacted so that we cannot get enough heat to kill the seeds?

How was it done?

To set up for WB it was a simple modification to the rear of the header to drop the material into a windrow. This was simple to achieve on my harvester by building two simple chutes at the rear of the header to direct all the trash from the header into a row of about 60cm wide (Figure 2).

Figure 2 Two pieces of sheet metal arranged to direct the entire trash fraction from the header into a distinct windrow

Other than this modification, the only additional change was to my harvesting technique. The weed seed heads need to be cut, collected and dropped in the trash windrow for burning later. To achieve this harvesting height had to be set lower than normal. The WA experience suggests this is approximately 15cm high, which has implications for uneven and/or rocky ground. It is also dictated by how high the ryegrass is growing, and whether it has lodged as occurred in 2010 and 2011 due to wet conditions.

The modifications are simple and gave no problems through the harvest period. If I didn't wish to windrow a paddock, it only took ten minutes to remove four bolts and re connect the straw spreaders. The modifications produced the desired 60cm windrow (Figure 3).

Fallow implications

The management of the summer fallow was not affected other than on the first fallow spray. This spray was delayed by a couple of days, to allow for all the weeds to emerge through the extra trash layers in the windrow.

Removing more material during harvest did result in a reduction in ground cover for the fallow period. No trash is spread behind the machine, which may have some impact on fallow efficiency although as can be seen in Figure 3 there is still a significant level of stubble remaining. However, this is a penalty I am willing to incur if it allows me to extend the life of a range of herbicides on my farm, most of which are very cheap and keep my cost of production lower.

Burning

Burning commenced in the final days of March, with the need to burn early enough in the year to get the temperature hot enough to kill the seeds being offset by concerns that the fire would burn the whole paddock.

Figure 3 Unburnt windrows following harvest

WA grower Doug Smith has found using the FESA McArthur Fire Weather Index to be very useful in selecting a suitable day and time of day for burning (Peltzer, 2011). This index takes into account wind speed, temperature and humidity to calculate fire potential under those conditions. It is best to have a fire that does not move too quickly as well. A fire that is fanned by strong winds can tend to “run” along the top of the windrow, and either not generate sufficient heat in the windrow to kill seeds, leave some material unburnt altogether or increase the risks of the fire escaping the windrows.

In my experience, I found warm temperatures of late afternoon with a steady cross wind was best to burn. Most days, I was lighting the fires around 4pm and most fires had burnt out by 10pm which was still within the conditions considered optimal by Doug Smith’s experiences.

In my first year with WB I burnt 100 ha of wheat stubble and experienced no fire escapes, despite the crop yielding 3.2t/ha. It must be remembered that the crop is harvested quite short to capture as many weed seed heads as possible. This leaves much shorter stubble than you normally associate with higher yielding crops.

The windrows were lit in a grid pattern, with each fire within the windrow separated by the header width one way and approximately 100m along the row. Because of this, each fire had a small front and it was noticed they did not develop the intensities common in general stubble burns. Normal stubble or grass fires often build intensity through their own heat generation, with the drafts they create tending to fan them along.

Another key concern was that rainfall on the windrows over summer would have reduced the ability to effectively burn them. Over 90mm of rain fell early in March and another 10mm just 10 days prior to burning. However the windrows dried out well, possibly due to the fact that the windrow had thatched itself repelling much of the water off rather than letting it through. So although the soil surface under the row was moist, the fire burnt completely to the bottom of the windrow provided it was burnt under optimal conditions. However, burning outside this window, where the critical heat was not achieved, saw many of the weed seeds survive (Figure 5).

Figure 4: Windrow burnt successfully with no escapes

Figure 5: Windrow burnt in early May in poor conditions did not kill the ryegrass weed seeds as seen in the emerging canola crop the following year.

One other advantage that I found with windrow burning is that in heavy crops it reduced my remaining stubble loads at sowing the follow year. With my tine seeder, I would have had to burn the whole paddock to allow seeding, but this system allowed me to retain most of my stubble and controlled many of my problems weeds in the process.

In 2012 I have windrowed both my canola and wheat and look forward to seeing the results in my second year.

Other grower experiences & issues

Whilst still in its infancy, a number of growers have been experimenting with WB. A number of challenges discovered to date include:

Stubble

Systems and areas that generate high stubble loads present the greatest challenge when it comes to the burning process. Tined implements throw dirt over the inter-row, at least partially covering old stubble so there is less on the surface and it is more prone to being broken down. Disc machines leave much more trash on the surface and allows for accumulation of stubble over consecutive years. Local experience has shown this to increase the risk of losing the whole paddock during burning, particularly if there have been consecutive higher yielding cereal crops.

Anecdotally, canola and pulse stubbles have been burnt successfully. They have the advantage in that they are often harvested or swathed quite low to the ground anyway, thus reducing or eliminating any harvest inefficiencies. This is likely to be a common use scenario for growers with tined machines. Those with disc machines will need to experiment to determine the most effective and safe option, i.e. whether to burn a cereal windrow after a pulse/canola crop or *vice versa*. Seasonal variations in weed burden, crop residue and harvest logistics will also affect the decision.

Continually burning windrows in a tramline situation could lead to some issues, such as nutrient accumulation. This is another reason to commence the process now, so annual burning does not have to occur. However, there are options for overcoming this issue, such as offsetting the windrow each year, and considering the other harvest weed seed alternatives.

Machinery configuration

There are many harvesters found in growers' paddocks, and so a wide range of methods to obtain a windrow. The key point is to produce a windrow of around 60cm in width to ensure adequate heat is generated. An important consideration is to ensure it is a quick process to add or remove the modification, so changes can easily occur both between and within paddocks if desired.

One problem encountered in the 2012 harvest was with a low drawbar hitch on a tractor-chaser bin unit working on tramlines. The drawbar tended to drag in the windrow, creating a bulldozing effect. Altering the hitch or fixing some sort of rubber belting to reduce the windrow contacting catch points may be possible solutions to this problem.

Burn time and smoke

One of the challenges of the strategy is learning how to manage the burning process and the smoke produced. It is a labour-intensive process, so strategies need to be developed that allow it to occur in the most time efficient manner. These include lighting windrows quickly using vehicles and custom made fire-lighters and using weather forecasts to ensure the burn is carried out under optimal conditions.

Because the windrows can burn for several hours, the amount of smoke produced can be significant. This can have direct implications for neighbours, principally in closely settled areas. However, it also can generate negative perceptions when observed by people not familiar with the strategy and its aims.

Which paddocks to target and when?

Although this paper has been discussing WB in the context of resistance management, it is equally valuable in terms of general weed control. It is known that no herbicides are 100% effective, particularly when applied in sub-optimal conditions, so there will generally be escapes in most paddock applications of herbicides. Because weed dynamics are driven by numbers of viable seed returned to the seedbank, WB has a role to play in reducing the weed burden in all situations.

Therefore, in deciding which paddocks to burn, the likelihood of success should be driving the decision, rather than the resistance status. This may mean some paddocks can be windrow burnt every year. Others will not be suited; namely very uneven surfaces and those with obstacles such as rocks, because if the header can't harvest low enough (15cm), too many ryegrass heads will be left behind. Similarly, there may be situations where stubble cover must be retained (e.g. a highly fragile soil). If the paddock has a high stubble load and the risk of a fire getting away is high, then WB may not be the answer in this instance. Very wet harvest conditions provide another challenge, as the ryegrass tends to lodge below the height of the cutter bar.

However, these challenges should not be used as an excuse not to employ the strategy, rather solutions must be found to the problems. This is another reason to start experimenting with WB sooner rather than later.

It is important to realise that WB is a complementary strategy to herbicide use. It should be employed not only to keep weed numbers low, but also to delay the onset of resistance. Delaying its implementation until after resistance develops greatly reduces the effectiveness of the strategy.

In summary

The critical point to remember is that most growers in this area still have many herbicide modes available to them. The question is for how long?

In our current farming systems, we struggle to break free of our reliance on herbicides and to implement alternate control techniques. WB is one such option that allows us to maintain our current systems with little change but have significant impacts on the development of resistance. However, it requires us to have a complete shift in the way we think about weed management, and has implications on other areas of farm management (e.g. labour).

By experimenting with and perfecting techniques such as WB within our systems, they can extend the life of herbicides on their farm. This may mean only needing to WB a portion of the paddocks each year. The alternative if we fail to adopt change can be found in WA, where many growers have to WB every paddock, every year if they wish to control their weed populations and continue to farm successfully. For them, there are very few solutions left available to them in a drum, and the implications for cost of production and labour are profound.

Useful links

Windrow burning in WA: http://www.youtube.com/watch?v=Hp_3tAI-VZY

Maurie's experience locally: http://www.youtube.com/watch?v=vfpvscKiZd8

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