WESTERN
SEPTEMBER 2018

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GROWNOTES™

GRDC
GRAINS RESEARCH
& DEVELOPMENT
CORPORATION

BARLEY

SECTION 12

HARVEST

PRE-HARVEST SWATHING | HARVESTING BARLEY IN WA | HEADER SETTINGS | DELAYED HARVEST ISSUES AND MANAGEMENT | FIRE PREVENTION | PRIORITISING SAFETY | RECEIVAL STANDARDS | HARVEST WEED-SEED CONTROL

Harvest

In Western Australia (WA), barley is generally harvested from October to December, prior to wheat, which provides some spread of harvest timing. Barley yield can be expected to be similar to or better than wheat yield. The crop dries down well and desiccation is generally not necessary unless late weed growth needs to be controlled. [1]

Growers should note that glyphosate is not registered for late season application on malt or food barley in Australia. Any malting barley treated with glyphosate prior to harvest must be declared and will be received as feed grade. [2]

12.1 Pre-harvest swathing

Swathing (also referred to as windrowing) is a simple means of speeding up the drying of grain while retaining quality. Swathing involves cutting the crop and placing it in rows held together by interlaced straws, supported above the ground by the remaining stubble. It involves cutting the crop when the grain has reached the physiological mature stage (moisture usually at 20–30%). The crop is then allowed to dry in the swaths until the moisture content is below 12.5%, when it is harvested using a special pick-up front attachment on the header. Swathing is one of the options more frequently used by growers in the southern coastal areas where the likelihood of rainfall at harvest is highest. [3] It also improves harvest weed seed management techniques because all the weeds are captured in the swath before any seeds have time to shed.

Swathing has many advantages:

- Swathed barley matures more rapidly and is ready to harvest 5–15 days earlier than if left standing. This effectively reduces the period that the crop is exposed to potentially damaging rains and is a cheaper way of drying down the crop
- Yield loss from lodging and head drop is minimised while the crop is in the swath
- Swathing helps even out the maturity of the crop and dry out any green weeds that might contaminate the crop
- Swathed barley is drier than grain in a standing crop so harvest can start earlier in the day and continue later than for a standing crop

These advantages must be balanced against a number of disadvantages, including:

- additional costs in the purchase or contract costs of a swather and an additional pass compared with direct heading
- fewer hectares covered per hour when harvesting (approximately 20% slower);
- a possible increased drying time of a swath in prolonged wet conditions, reducing its quality
- possible collection of soil, rocks, beetles and other material, contaminating the sample

When to swath

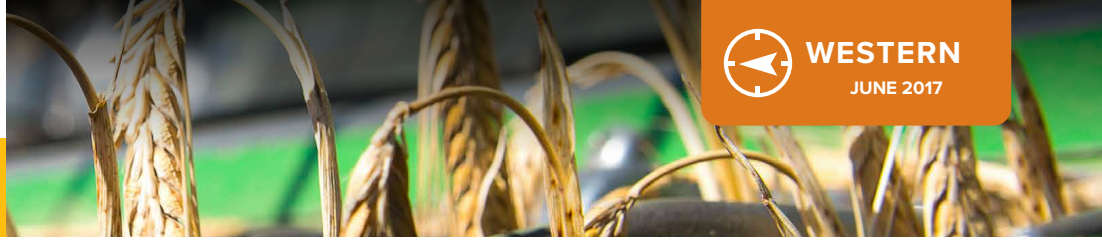
Swathing can begin when grain moisture content is below 35% and when the grain is at the medium dough stage and is hard but can still be dented with the thumbnail. It is better to swath early to prevent losses from shedding and lodging, but do not swath when the ground is wet after rain.

Grainfilling studies have shown barley reaches maximum grain weight when all of the green tissue has gone from the flag leaf sheath and the peduncle (stem immediately

1 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting

2 GrainCorp (2016) Harvest Alert. http://www.graincorp.com.au/

3 DAFWA (2016) Barley production—harvest and grain quality. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2212



below the head). Avoid swathing too early as the grain is not fully developed and this will give small pinched grain. While it is often easier to swath later than earlier, the swaths of a ripe crop may not interlock well enough to withstand disturbance from a strong wind.

High-yielding crops are likely to gain more from swathing than low-yielding crops. Generally, crops that are likely to yield less than 2 t/ha should not be swathed. [4]

Swathing and harvesting operation

The crop can be swathed in any direction but is usually cut across the sowing direction or at a 45-degree angle for crops with a wider row spacing. This allows the swath to sit up better on the stubble. Swathing is not recommended for paddocks where the crop row spacing is over 25 cm.

Avoid placing swaths in the same location each year. Adjust to distribute the residue across the paddock so nutrients are not concentrated in one place.

Swather size or width of cut should match header capacity. A double-up attachment to the swather or placing two swaths side by side requires a larger capacity header and concentrates the residue in a narrow band within the paddock.

The cutting height must be adjusted to allow for sufficient straw on the head to keep the swath together (minimum 30 cm) and sufficient stubble height to support the windrow. It is recommended to start the swath height at 10–20 cm above the ground (one-third height of crop or 'beer can' height) and then adjust to produce an even swath with well-interlaced straws that sit above the ground, allowing good air circulation and rapid drying should rain occur.

When the swath is picked up, the reel should be rotating slightly faster than ground speed, but not so fast that heads are knocked off the stems. The conveyor canvas should be revolving sufficiently fast so it does not clog with crop material. Rows pick up best when the header follows the direction of the swath (heads first).

If the crop is too thin or the stubble too short to support the swath above the ground, the crop should not be swathed. Heads on the ground may sprout and attempts to pick up heads lying close to the soil surface will pick up soil.

Harvesting of the swathed crop must be completed as soon as possible, ideally within 10 days of swathing. If swaths are left too long and are subjected to long periods of wetting (more than 25 mm of rain over 4 to 8 days), grain may sprout and become stained and possibly contaminated with bronze field beetle. Following extensive rain, some growers have attempted to turn or fluff the swaths using a rake or hay baler with an open back door. There has been mixed success with this practice, particularly with heavy swaths. Many growers have reported in hindsight it would have been better to not have touched the swath row but to have picked up as normal.

One of the major sources of contamination in swath barley is when the stubble is torn out during the swathing operation. This generally occurs when the swather is operated at too high a ground speed or when trying to swath when the straw is tough due to it being cool or damp. [5]

12.2 Harvesting barley in WA

Maintaining the quality of grain is dependent on the correct and timely harvesting of the grain, and its management and storage once removed from the paddock (Photo 1).

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GRDC (2010) Managing the weed seedbank. Fact sheet.

GRDC (2014): Harvest systems combined to crush weed-seed resistance. Ground Cover 113.

GRDC (2013) The effectiveness of on-farm methods of weed seed collection at harvest time: Case studies of growers in the Albany Port Zone.

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GRDC (2011) Development of the Harrington Seed Destructor.

GRDC (2015) The nuts and bolts of efficient and effective windrow burning.

GRDC (2013) Windrow burning for weed control—WA fad or viable option for the east.

4 DAFWA (2016) Barley production—harvest and grain quality. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2212

5 DAFWA (2016) Barley production—harvest and grain quality, https://www.agric.wa.gov.au/barley/barley-production-harvest-and-grain-quality?page=0,0

Photo 1: *Harvesting barley.*

Source: DAFWA

The harvesting operation is crucial in determining the grain yield and quality of barley. For malting barley, unless the grain has a germination percentage above 98% it is not suitable for sale to maltsters. How the barley grain is handled at harvest is critical as viability of the grain must be maintained.

The reduction in the quality of barley for use in the malting and brewing as well as feed industries may be a result of:

- skinning the grain due to over threshing
- storing wet due to harvesting at high grain moisture without aeration
- drying to temperatures above 43°C

Because of this, the potential for a premium price and the possibility of head loss or weather damage means malting barley should be harvested as soon as the crop is at a moisture content that is suitable for storage (Photo 2).

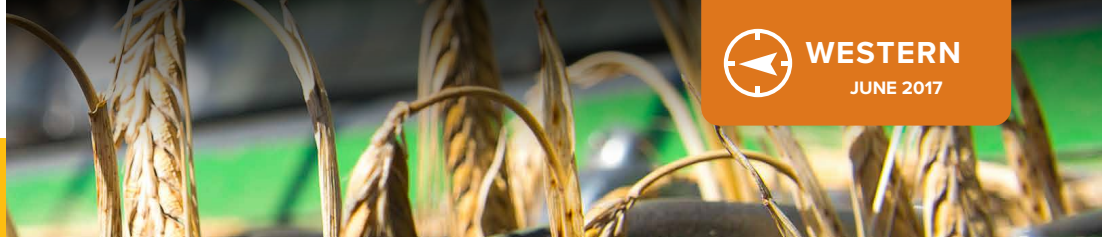
Photo 2: *Barley heads.*

Source: DAFWA

12.3 Header settings

Harvest and handling are particularly important for malting barley. Even minor damage to the seed can affect its ability to germinate. Cracked grains, skinned or partially skinned grains and grains killed through damage to the germ do not malt properly.

When examining a barley seed sample for damage, look at individual grains and not just a mass of grain. Always examine the back of the grain first and ignore the crease side. Severe cracking and germ damage are nearly always accompanied by a high degree of skinning. The most common causes for this are:



- **Drum speed too high:** use only the slowest drum speed that will effectively thresh the grain from the barley head. A higher drum speed is needed when harvesting crops not properly ripe and can cause serious grain damage
- **An incorrectly adjusted or warped concave.** Check the setting frequently during the day. If the thresher drum speed is correct, concave adjustments should cope with the changes in temperature and other harvesting conditions met during the day

The airflow may need to be increased slightly to obtain a clean sample. The application of heat can also affect germination of grain and this should be taken into account if artificial drying is intended for malting-quality barley. [6]

It is important to note once the moisture in the grain falls below 10%, the grain becomes susceptible to skinning due to over threshing. Skinned barley takes up moisture faster during the steeping phase of the malting process than grain with its husk intact. This can lead to death of the grain because it cannot regulate water uptake or excessive root and shoot growth. For the brewer, this leads to reduced alcohol yield. Skinned grain is very noticeable to grain buyers in the dried malt sample as it turns pink during kilning. Correct set-up of the header is very important to ensure that overthreshing of the barley grain does not occur.

12.3.1 Direct heading of dry barley

The simplest and most common harvesting method for barley is to wait until the grain has ripened and dried to a moisture content of less than 12% so it can be delivered directly to the receival point.

Once the crop is ripe, harvest as soon as possible to reduce the potential losses from wind damage or weathering. It is important when direct heading barley to:

- prevent the skinning and cracking of grain by correctly setting up the harvester
- avoid contamination by ensuring the harvesting and grain movement equipment is clean
- reduce grain losses and damage by monitoring the sample throughout the day and adjust thresher speeds and concave to suit conditions as they change
- use correct screens to remove small grain, weed seed and contaminants

This may cause considerable delays to the harvesting operation and increase the risk of head loss or grain being discoloured by early summer rains.

12.3.2 Monitoring grain loss

Monitoring for grain loss should begin before harvest. A seed count on the ground of >26 seeds in an area 10 cm by 100 cm means a loss of >100 kg/ha. After checking for any grain on the ground prior to harvest, growers should check after beginning harvest to determine any harvest loss. It is recommended that a minimum of 10 counts be taken and averaged. [7,8]

FAQ

12.4 Delayed harvest issues and management

Because mature barley does not stand weather damage as well as wheat, it is important not to delay harvest. Lodging can be a problem and patches of unripe crop on headlands and low-lying areas should be avoided, because unripe grains can contaminate samples and cause downgrading. [9]

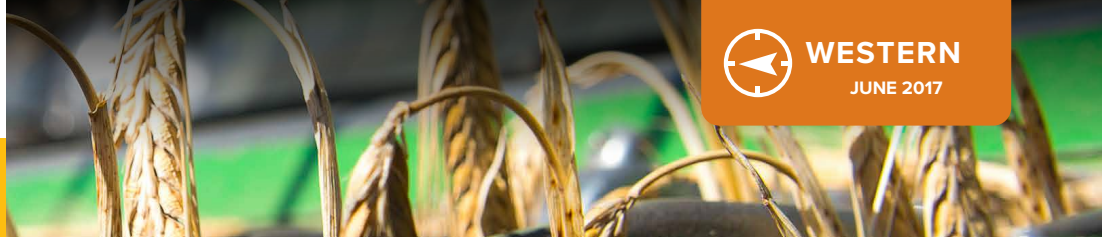
Delayed harvest can:

6 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting

7 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting

8 Agriculture Victoria (2012) Estimating crop yields and crop losses. AG0104, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/estimating-crop-yields-and-crop-losses

9 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting



- increase the lodging risk resulting in a slower harvest
- reduce grain yield (largely through head loss)
- decease hectolitre weight (through grain swelling)
- decrease screenings (through grain swelling)
- increase or decrease grain brightness (depending on the level and timing of harvest rainfall)
- decrease grain hardness thereby increasing grain breakage during pearling for shochu manufacture
- increase pre-harvest sprouting risk, therefore shortening the optimal storage duration
- influence the sensitivity of the grain to water during steeping in the malt house
- increase the rate of germination

Adverse weather conditions can cause significant delays at harvest, resulting in the crop standing in the field for longer than is ideal. These crucial delays affect not only grain yield, but grain quality traits important for meeting malt barley receival standards. End use traits such as pre-harvest sprouting, dormancy, water sensitivity and grain hardness can also be influenced by harvest timing.

In some cases, delays in harvest can be beneficial, such as bleaching of the discoloured grain due to sunshine, but the negative impacts from delayed harvest usually outweigh the positives.

Delayed harvest impacts

Research conducted in WA evaluated a total of 19 malt (or under malt accreditation) and food barley varieties across six trials at three locations (Gibson, Northam and Katanning) between 2009 and 2011.

The study assessed the effect delays in harvest date might have upon the grain yield and quality of a range of upcoming and existing malt or food barley varieties.

In all barley growing regions, there is always a chance of harvest being interrupted by rainfall. The trial series showed for the varieties assessed, rainfall and delays in harvest can lead to:

- increased lodging risk
- losses of grain yield
- reduced hectolitre weight
- a possible increase or decrease in grain brightness (dependent on the amount and distribution of rainfall at harvest);
- decreased grain hardness and increased pre-germination risk

In the grower's favour was the likely decrease in screenings, with no change expected in grain protein concentration.

For maltsters, delayed harvest can impact processing logistics, the level and rate of germination expected, as well as the steeping program to be used.

Delays in harvest date did not impact one variety more than another for most of the grain quality traits assessed at receival (hectolitre weight, screenings and grain protein). There was some evidence however, that Bass$^{\Phi}$, Baudin$^{\Phi}$ and Flinders$^{\Phi}$ may weather or bleach slightly differently to the other varieties evaluated.

Varietal differences were associated with straw strength and risk of head loss. To minimise the risk associated with harvest delays, especially on the south coast of WA, growers should consider sowing only manageable areas of susceptible varieties or look to swath susceptible varieties.

Baudin$^{\Phi}$ was the only variety that could be delayed in harvest date by more than 6 weeks in all sites with minimal loss in yield or quality.

Varieties with a high risk of pre-harvest spouting reacted differently (for germination related traits) to delayed harvest than those with a low risk. Whilst those effects on

grain quality did not influence the 'receivability' of the barley, they could influence what an end user (ie. maltster) might do with the grain. [10]

Although the trials were conducted between 2009 and 2011, the varieties Baudin$^{\Phi}$, Bass$^{\Phi}$, Flinders$^{\Phi}$ and La Trobe$^{\Phi}$ are still commonly grown in WA.

The trials were continued in 2015 and 2016 and this research included newer varieties including Scope CL$^{\Phi}$, Granger$^{\Phi}$, Spartacus CL$^{\Phi}$ and Compass$^{\Phi}$.

The study found Scope CL$^{\Phi}$ is comparable to Buloke$^{\Phi}$, which was tested in the original trials, and 2015 trial results suggest that these varieties respond similarly to harvesting delays. [11]

For growers, varietal differences in response to harvest delays were only observed for lodging, head loss and grain brightness with varieties responding similarly for the grain receival traits hectolitre weight, screenings and grain protein concentration.

Information from the trials, including 2015 research, is incorporated into the new 2017 Barley variety sowing guide for Western Australia, released by DAFWA and co-funded by the GRDC.

12.4.1 Cost-effective harvest and logistics

Growers need to consider how to avoid the losses arising from wet weather during harvest. Options include increasing the capacity or number of the grower-owned header(s), bringing in contractors, using methods to improve harvesting efficiency (chaser and mother bins) and using on-farm storage.

Key points:

- Machinery costs are driven by scale: the challenge is to keep the capacity of the machine matched to scale (current and anticipated).
- Harvesting costs depend on the header throughput. Doubling header capacity (e.g. with two machines) increases harvesting costs from $16.47/t to $24.40/t (inclusive of chaser bin) with only half the throughput through each of the two machines.
- It is not necessary to double harvesting capacity with two headers to avoid weather damage, but header capacity needs to be enough to get the crop off in reasonable time, so as not to affect other activities.
- Any excess capacity available through having two headers might be used to provide contracting services to neighbours.
- Mother bins are a cost-effective form of short-term, in-paddock storage to provide a buffer between the header and the trucks. Two mother bins might be practical for large (≥3,000 ha) grain-growing operations. Round bins are a cheaper and cost-effective option.
- Grain bags are an alternative means of keeping the grain away from the header during harvest through short-term storage in the paddock.
- With good carriers, it may be unnecessary to own enough trucks to keep up with high-capacity headers. [12]

12.5 Fire prevention

Grain growers must take precautions during the harvest season when operating machinery in extreme fire conditions. Fires are regularly experienced during harvest, in stubble as well as standing crops. The main cause is hot machinery combined with combustible material. This is exacerbated on hot, dry, windy days. Seasonal

10 J Curry, B Paynter, A Hills (2016) Response of barley varieties to delays in harvest date. GRDC Grains Research Update, 29 February–1 March 2016, http://www.giwa.org.au/2016researchupdates

11 N Lee (2016) Barley harvest results can help grower decision making. GRDC Media Centre, https://grdc.com.au/Media-Centre/Media-News/West/2016/10/Barley-harvest-results-can-help-grower-decision-making

12 A. Polkinghorne (2011) Cost effect harvest and logistics. GRDC Update Paper.

conditions can also contribute to lower moisture content in grain and therefore a higher risk of fires. [13]

With research showing that 12 harvesters, on average, are burnt to the ground every year in Australia, agricultural engineers encourage care in keeping headers clean to reduce the potential for crop and machinery losses (Photo 3).

Photo 3: *Keeping headers clean can reduce the risk of fire.*

Source: Rebecca Thyer

Key points:

- Most harvester fires start in the engine or engine bay.
- Fires can be caused by failed bearings, brakes and electricals, and rock strikes.
- Regular removal of flammable material from the engine bay is urged. [14]

12.5.1 Using machinery

To prevent machinery fires, it is imperative that headers, chaser bins, tractors and augers be regularly cleaned, serviced and maintained. Keeping fire-fighting equipment available and maintained is not just common sense—it is a legal requirement.

Take great care when using machiney outdoors:

- Be extremely careful when using cutters and welders to repair plant equipment, including angle grinders, welders and cutting equipment
- Ensure that machinery components, including brakes and bearings, do not overheat; these components can drop hot metal onto the ground, starting a fire
- Use machinery correctly; incorrect usage can cause it to overheat and ignite
- Be aware that blades of slashers, mowers and similar equipment may hit rocks or metal, causing sparks to ignite dry grass
- Avoid using machinery during inappropriate weather conditions, such as high temperatures, low humidity and windy conditions

13 NSW Rural Fire Service. Farm fire safety. Farm FireWise. NSW Government, http://www.rfs.nsw.gov.au/plan-and-prepare/prepare-your-property/farm-fire-safety

14 N Baxter (2012) A few steps to preventing header fires. GRDC Ground Cover Issue 101, 2 November 2011, http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-101/A-few-steps-to-preventing-header-fires

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GRDC (2016) Cost effective investment in machinery, Fact sheet.

GRDC (2016) Employing seasonal labour for Western Australia's grain industry, Fact sheet.

GRDC (2016) Machinery purchase, Fact sheet.

CBH Group – Growers Harvest Informat/ion

GRDC Webinars: Beginner's guide to harvest weed seed control

GRDC (2013) The effectiveness of on-farm methods of weed seed collection at harvest time: Case studies of growers in the Albany Port Zone

- Do maintenance and repairs in a hazard-free, clean working area such as on bare ground or concrete or in a workshop, rather than in the field
- Keep machinery clean and as free from fine debris as possible to reduce risk of on-board ignitions [15]
- Follow local government bans on fires and movement of vehicles

12.6 Prioritising safety

Growers experience intense pressure and fatigue during harvest, and there is usually a higher number of inexperienced seasonal workers employed. Risks can be reduced by growers employing key strategies, such as:

- Make sure all guards on machinery and equipment (harvesters, tractors, chaser bins, silos, field bins and auger), are in place.
- Ensure all people working during harvest – whether employees, contractors or family members – are inducted into the way safety will be managed during the harvest, including fatigue. Expectations for safety should be made very clear to everyone.
- Have a standard policy where all harvester/machinery engines are stopped and keys removed from the ignition during maintenance. Before working under raised hydraulics, header fronts and combs, ensure hydraulic and ram locks have been fitted and that the comb is chocked and supported. Replace all guards after servicing/repairs.
- Make everyone aware of electrical hazards and where they exist on the property. Consider having no-go areas, if practical. [16]

12.7 Receival standards

The minimum protein level acceptable for malt-grade barley is 9%. Malt protein content is reported at 0% moisture (dry), which will be 1–1.5% higher than the 'as-is' basis commonly used for feed grain. In line with malting industry standards, Co-operative Bulk Handling Ltd (CBH) reports all protein figures at 0% moisture basis. Feedlots generally use the 'as-is' figure.

Growers should check receival standards with CBH or their local grain merchant. Updated specifications, and other relevant information, are usually available from September each season. Other purchasers of barley grain may use different specifications. [17]

Most grain purchasers will base their quality requirements on Grain Trade Australia (GTA) standards. For feed barley, grain is required to meet screenings and hectolitre weight specifications. For malting barley, as well as screenings and hectolitre weights, there are requirements for retention (above the 2.5 mm screen) and protein. [18]

12.8 Harvest weed-seed control

For information on harvest weed seed control, see Section 6.8: Harvest weed seed control.

15 NSW Rural Fire Service. Farm fire safety. Farm Firewise, NSW Government, http://www.rfs.nsw.gov.au/plan-and-prepare/prepare-your-property/farm-fire-safety

16 S Watt (2016) Prioritising safety this harvest. GRDC Media, 10 October 2016, https://grdc.com.au/Media-Centre/Media-News/National/2016/10/Prioritising-safety-this-harvest

17 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting

18 DAF Qld (2012) Barley planting, nutrition and harvesting. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/barley/planting-nutrition-harvesting

12.8.1 Intercepting annual weed seed

In WA, high frequencies of herbicide-resistant annual weed populations have been driving farming practices for the last decade and techniques targeting weed seeds during harvest have been widely adopted. At crop harvest, much of the total seed production for the dominant weed species is collected by the harvester (Table 1). Additionally, for some of these species, such as wild radish, high levels of seed are are retained rather than shed over a four week period (Figure 1). Therefore, the collection and management of the weed-seed-bearing chaff fraction can result in significant reductions in population densities of annual weeds.

Table 1: *Proportion of total weed-seed production retained above a low harvest cutting height (15 cm)*

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

Source: AHRI

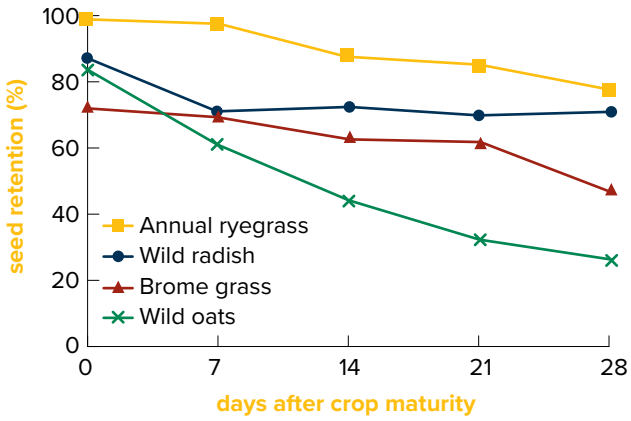


Figure 1: *Seed retention above a harvest height of 15 cm over the first 4 weeks of harvest for the major crop weeds of Western Australian wheat crops.*

Source: AHRI

Lower in-crop weed densities are easier to manage and their potential development as herbicide-resistant populations is dramatically reduced. WA growers have been instrumental in the development of several systems that reduce input of weeds into the seedbank. The adoption of these systems has been critical for the continuation of intensive cropping systems. [19]

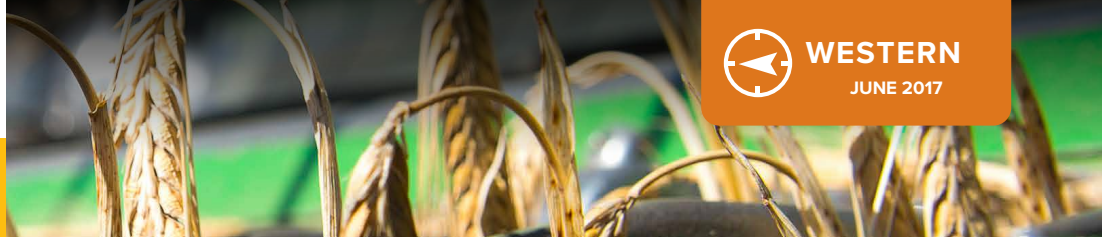
12.8.2 Burning of narrow windrow

During traditional whole-paddock stubble burning, the very high temperatures needed for weed-seed destruction are not sustained for long enough to kill most weed seeds. By concentrating harvest residues and weed seed into a narrow windrow, fuel load is increased and the period of high temperatures extends to several minutes, improving the kill of weed seeds.

MORE INFORMATION

IWM in Australian cropping systems: Section 5. Tactics

19 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012



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GRDC (2014) Narrow windrow burning Driving Agronomy Podcasts.

GRDC (2013) Developments in stubble retention. Report.

IWM Section 5. Tactics

Weed seed bank destruction—windrow chute design

Weed seed bank destruction—header setup and tips for narrow windrowing

Weed seed bank destruction—narrow windrow burning

Weed seed bank destruction—burning windrows safely

Weed seed bank destruction—nutrient Losses: comparing chaff heaps with narrow windrows

Weed seed bank destruction—vary windrow placement to avoid potassium concentration

Establishing narrow windrows suitable for autumn burning (Photo 4 and Photo 1) is achieved by attaching chutes to the rear of the harvester to concentrate the straw and chaff residues as they exit. This concentration of residue increases the seed-destruction potential of residue burning. With more fuel in these narrow windrows, the residues burn hotter than standing stubbles or even conventional windrows. Weed-seed kill levels of 99% for both annual ryegrass and wild radish have been recorded from the burning of wheat, canola and lupin stubble windrows. [20]

Windrow burning can work effectively in high yield crops, even above 5 t/ha. Barley crops can be burned successfully, but growers need to do everything correctly. This includes:

- Aim to keep windrows to about 500–600 mm wide
- Make sure chutes direct all chaff and weed seeds into windrow
- Do not over-thresh crops. This leads to rows with little or no air flow, making rows smoulder rather than burn. Rows that smoulder, do get hot enough to kill weed seeds
- Make sure the chute does not restrict air flow from the cleaning fan of the harvester. Most chutes need to open back and front. Closing the front reduces harvest capacity in 4t/ha plus crops
- Try not to run over rows with headers/chaser bins etc., as this crushes the rows. Like over-threshing, it reduces the air flow in burns
- Slow the harvester ground speed at the end of the runs so the sieves empty at the same time as the rotors. This prevents tails of seeds with no straw mixed in that would be difficult to burn

While some types of barley produce good rows it can be tricky not to burn the whole paddock. The low fluffy flag can carry the fire between the rows.

By changing from Gairdner to Hindmarsh$^{\Phi}$, which produces a much better straw out of the back of the header, there are fewer issues with flat burning paddocks. This is because the rows are better suited to night-time burning. The bigger windrows aren't smashed, which allows the straw to burn hot enough to kill seeds even when the Fire Danger Index (FDI) is low so that the fire won't spread between rows.

High yielding crops of Scope CL$^{\Phi}$ and Buloke$^{\Phi}$ can be burned successfully. With barley, the conditions are the most important factor where the humidity needs to be at 75%, the wind <12 km/h and temperature around 12°C. These conditions generally occur between 9pm and 3am. [21]

20 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012

21 D Smith (2015) Burning big crop windrows–it can be done. GRDC Update Papers, 20 August 2015, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/08/Burning-big-crop-windrows-it-can-be-done

VIDEOS

Weed seed bank destruction—an integrated approach to weed management

Weed seed bank destruction—more efficient use of chaff carts

Weed seed bank destruction—wild radish seed

Weed seed bank destruction—burning chaff dumps

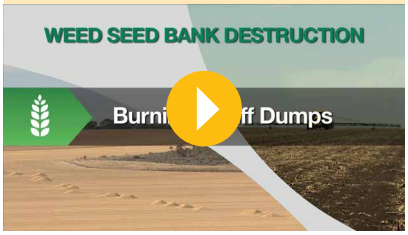


Photo 4: *Harvest in action—producing narrow chaff rows for burning the following autumn.*

Source: A Storrie

Photo 5: *Windrow burning.*

Source: Penny Heuston

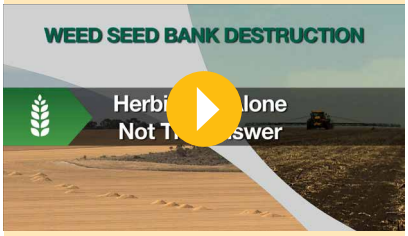
12.8.3 Chaff carts

Chaff carts are towed behind headers during harvest to collect the chaff fraction as it exits the harvester (Photo 6). Collected piles of chaff are then either burnt the following autumn or used as a source of stock feed. [22]

22 GRDC, Section 7: Managing weeds at harvest. GRDC Integrated Weed Management Hub, https://grdc.com.au/resources-and-publications/iwmhub/section-7-managing-weeds-at-harvest

VIDEOS

Weed seed bank destruction—herbicides alone not the answer



Weed seed bank destruction—seeing results from integrated weed management

Over the Fence: Windrow burning beats wild radish

Weed seed bank destruction—seeing results from integrated weed management

Photo 6: *Chaff cart in action*

Source: Trent Butcher, ConsultAg

The weed-seed collection efficiency of several commercially operating harvesters with attached chaff carts was evaluated by the *Australian Herbicide Resistance Initiative (*AHRI). Harvesters were found to collect 75–85% of annual ryegrass seeds and 85–95% of wild radish seeds entering the front of the header during the harvest operation. Collected chaff must be managed to remove weed seeds from the cropping system. [23]

12.8.4 Bale-direct systems

An alternative to the in-situ burning or grazing of chaff, the bale-direct system uses a large baler attached to the back of the harvester to collect all chaff and straw material as it exits the harvester. As well as removing weed seeds, the baled material has an economic value as a livestock feed source. [24] However, as with all baling systems, consideration must be given to nutrient removal. [25]

The bale-direct system was developed by the Shields family in Wongan Hills as a means of improving straw hay production. It consists of a large square baler directly attached to the harvester that collects and bales all harvest residues. A significant secondary benefit is the collection and removal of annual weed seeds. Studies by AHRI determined that ~95% of annual ryegrass seed entering the harvester was collected in the bales. [26]

For the story of development of header-towed bailing systems, see: http://www.glenvar.com/.

12.8.5 Harrington Seed Destructor

The Harrington Seed Destructor (HSD) is the invention of Ray Harrington, a progressive farmer from Darkan, WA. Developed as a trail-behind unit, the HSD system comprises a chaff-processing cage mill and chaff and straw delivery systems. The retention of all harvest residues in the field reduces the loss and/or banding of nutrients and maintains all organic matter to protect the soil from wind and water erosion, as well as reducing evaporation loss, compared with windrow burning, chaff carts and baling. [27]

Evaluation under commercial harvest conditions by AHRI has determined the HSD process will destroy ≥95% of annual weed seed during harvest. A new version of the HSD, a prototype 'Integrated Harrington Seed Destructor', (iHSD) has been developed by engineers at the University of SA in collaboration with AHRI. [28,29]

23 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012

24 GRDC, Section 7: Managing weeds at harvest. GRDC Integrated Weed Management Hub, https://grdc.com.au/resources-and-publications/iwmhub/section-7-managing-weeds-at-harvest

25 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012

26 M Walsh, S Powles (2007) Management strategies for herbicide-resistant weed populations in Australian dryland crop production systems. Weed Technology 21, 332–338, http://www.jstor.org/stable/4495856?seq=1#page_scan_tab_contents

27 GRDC, Section 7: Managing weeds at harvest. GRDC Integrated Weed Management Hub, https://grdc.com.au/resources-and-publications/iwmhub/section-7-managing-weeds-at-harvest

28 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012

29 AHRI (2013) Weed Destructor integrated into harvester. Australian Herbicide Resistance Initiative, University of Western Australia, http://ahri.uwa.edu.au/weed-destructor-integrated-into-harvester/

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MORE INFORMATION

AHRI (2013) Weed Destructor integrated into harvester

IWM Section 5. Tactics

AHRI (2017) Harvest Weed Seed Control Systems are Similarly Effective on Rigid Ryegrass

http://ahri.uwa.edu.au/publications/harvest-weed-seed-control-systems-are-similarly-effective-on-rigid-ryegrass/

GRDC (2010) Managing the weed seedbank. Fact sheet.

GRDC (2014): Harvest systems combined to crush weed-seed resistance. Ground Cover 113.

GRDC (2013) The effectiveness of on-farm methods of weed seed collection at harvest time: Case studies of growers in the Albany Port Zone.

GRDC (2011) Development of the Harrington Seed Destructor.

GRDC (2015) The nuts and bolts of efficient and effective windrow burning.

GRDC (2013) Windrow burning for weed control—WA fad or viable option for the east.

The iHSD comprises of two hydraulically driven cage mills mounted within the rear of the harvester (just below the sieves). AHRI has determined the mills can destroy 93 to 99% of the weed seeds that enter them. [30]

For more information and expressions of interest, go to iHSD.com.

12.8.6 Chaff grinding

Processing of chaff sufficient to destroy any weed seeds that are present during the harvest operation, is the ideal system for large-scale Australian conservation cropping systems. Rendering weed seeds non-viable as they exit the harvester removes the need to collect, handle and/or burn large volumes of chaff and straw residues. The importance and potential industry benefits of this process have meant substantial interest in the development of an effective system.

30 AHRI (2016) The integrated Harrington Seed Destructor has arrived. Australian Herbicide Resistance Initiative, University of Western Australia, 8 March 2016, http://ahri.uwa.edu.au/ihsd/

VIDEOS

Weed seed destruction—beer can height

Weed seed bank destruction—Spear grass (Bromus spp.) an emerging problem

GCTV1: Integrated weed control & HSD

GCTV10: Harvester mounted weed destructor

VIDEOS

GRDC Webinar: A beginner's guide to harvest weed seed control

GCTV15: Harvest weed seed control

Weed seed destruction—weed seed management

Weed seed destruction—weed seed capture

OTHER VIDEOS

AHRI: Sustaining herbicides with harvest weed seed management

DAFWA: Burning windrows for weed control

Grassroots Agronomy: NWB Show and Tell video 1: paddock experiences in SNSW

Grassroots Agronomy: NWB Show and Tell video 2: chute designs from the growers' perspective

WeedSmart: Capture weed seeds at harvest: chaff carts

WeedSmart: Capture weed seeds at harvest: Harrington Seed Destructor

WeedSmart: Capture weed seeds at harvest: windrow burning

WeedSmart: Chaff carts as part of the arsenal

WeedSmart: Control harvest weed seed set with windrows and crop topping

WeedSmart: Grazing chaff dumps

WeedSmart: Narrow windrow burn like a pro

WeedSmart: Setting up your header for harvest weed seed control