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GRDC™
GROWNOTES™

GRDC™ GRAINS RESEARCH & DEVELOPMENT CORPORATION

WHEAT

SECTION 12

HARVEST

PRE-HARVEST SPRAYING WITH GLYPHOSATE | WET HARVEST ISSUES AND MANAGEMENT | FIRE PREVENTION | RECEIVAL STANDARDS | HARVEST WEED-SEED CONTROL | SUMMARY

SECTION 12

Harvest

Harvest can commence whenever the header is capable of giving a clean grain sample (Figure 1). This is usually when grain moisture is <20%. Where grain-drying facilities are available, harvesting can start well before the crop dries down to the required 12.5% moisture, reducing the time the crop has to stand at risk from weather damage in the field.

Grain density standard is 75 kg/hectolitre (hL), although wheat often achieves 80 kg/hL. [1]

Figure 1: Harvest under way.

More information

GRDC Fact Sheets: Pre-harvest herbicide (Northern, Western and Southern Regions)

12.1 Pre-harvest spraying with glyphosate

Timing of glyphosate application is important; certain glyphosates are registered for pre-harvest spraying, and several other groups for salvage control. For more information, visit: Public Chemical Registration Information System Search.

12.2 Wet harvest issues and management

Ideally, harvest begins as soon as the crop is mature or ripe. A cereal crop can be harvested any time after it reaches physiological maturity and dries down from about 20% moisture content (MC). In most situations, however, harvest does not begin as soon as the crop is ready. The actual start of harvest is usually dictated by the options each grain grower has available to deal with high moisture grain. For example, a grower with access to a heated air dryer could harvest at 18% MC and a grower with

[1] DAF Qld (2012) Harvesting and yield. Department of Agriculture and Fisheries, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/harvesting-information

aerated storage could harvest at ~15% MC, whereas a grower without high-moisture management techniques would have to wait until the moisture was <12.5%. [2]

12.2.1 Delaying harvest

Every day a harvestable crop stands in the paddock, it is exposed to ongoing yield loss and quality degradation (Figure 2). Yield is reduced by shedding, head loss and general exposure to the elements. This is measured as a loss of yield each day in dry matter (DM). Research on this topic in the 1980s at Esperance by M Bolland and J Richardson (from the then Western Australian Department of Agriculture) revealed daily DM losses for wheat of 0.18–0.53% and for barley of 0.25–0.75% (depending on the season and distance from the ocean).

Most growers have also experienced some form of grain quality loss due to delayed harvest and associated rain. Fungal growth reduces the end use possibilities.

These factors can combine to result in heavy discounts from a crop's net return. Time increases these risks, and ongoing exposure to moisture will eventually cause yield loss and development of one or more of these quality defects.

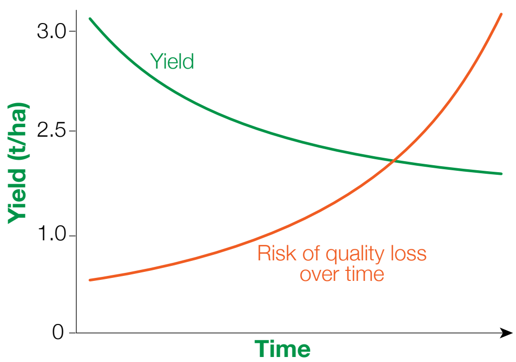

Figure 2: Yield loss and risk of quality loss over time

12.2.2 Weed management

Extreme wet weather during harvest across areas of the Australian winter cropping zone can present large problems with weed management for grain growers. Wet conditions can promote growth of weeds in the standing crop that may have been present prior to the rain, with many summer weeds germinating as soil temperatures increase. Growers will want to harvest the crops as quickly as possible to maintain grain quality. Herbicide residues are a real risk, and it is critical that only registered herbicides or those with a 'permit' are used prior to harvest and that harvest-withholding periods are strictly observed. These problems are greatly compounded if weeds resistant to glyphosate or paraquat are present. [3]

12.2.3 Seed retention

Saving viable grain seed following a wet harvest requires careful collection, storage, handling and subsequent planting. Retained seed must be graded and tested for germination and vigour.

All crops are susceptible to deterioration in seed quality during wet harvests. Symptoms can range from mild (a loose and wrinkled seed coat), to severe (seed staining and fully germinated seed). It is essential to recognise whether the damage is cosmetic or the symptom of seed-borne disease, and if it will affect germination.

[2] N Metz (2006) The WA guide to high moisture harvest management, grain storage and handling. CBH Group and South East Premium Wheat Growers Association, Perth, W. Aust, http://www.giwa.org.au/_literature_133719/SEPWA_and_CBH_Group_-_the_WA_Guide_to_high_moisture_harvest_management_grain_storage_and_handling

[3] Australian Glyphosate Sustainability Working Group (2011) Wet harvest poses difficult weed management decisions for grain growers. Australian Glyphosate Sustainability Working Group, http://glyphosateresistance.org.au/media%20releases/mr_111221_harvest_weed_management.pdf

Seed quality can also decline during storage, and growers are advised to test germination capacity before and during storage, and before planting. Generally, a germination percentage of 80% at planting is considered acceptable, but when testing at harvest, the germination percentage should be higher. Weather-damaged grain is likely to have a lower germination percentage and poorer vigour, so seeding rates should be adjusted accordingly.

With many weedy cereal crops in a wet season, desiccation or crop-topping is often necessary. Depending on timing and chemicals used, this could affect seed quality for sowing.

Growers are reminded that grain must not be retained for seed when glyphosate has been used in pre-harvest applications.

A laboratory seed test should be used to establish the germination percentage of on-farm, retained seed before sowing, especially if it has been damaged by weather. A vigour test is also recommended. Purchased seed will be certified and it should include details of germination percentage.

Key points:

- Ideally retain seed from grain harvested before rain.
- Weather-damaged grain is more susceptible to poor germination, low vigour and degradation during storage and handling, so extra care is needed.
- Harvest under conditions of low moisture and cool temperature. Storage temperature and moisture must be monitored and controlled.
- Germination percentage should be checked at harvest, during storage and before seeding. Low-germination seed should not be used.
- Correct seeding depth, conditions and agronomy are essential when sowing weather-damaged seed.

12.3 Fire prevention

Grain growers must take precautions during the harvest season. Operating of machinery in extreme fire conditions is dangerous, and all possible measures must be taken to minimise the risk of fire. 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 conditions can also contribute to lower moisture content in grain and therefore a greater risk of fires. [4]

12.3.1 Using machinery

To prevent machinery fires, it is imperative that all headers, chaser bins, tractors and augers be regularly cleaned and maintained. All machinery and vehicles must have an effective spark arrester fitted to the exhaust system. To prevent overheating of tractors, motorcycles, off-road vehicles and other mechanical equipment, all machinery needs to be properly serviced and maintained. Fire-fighting equipment must be available and maintained—it is not just common sense, it is a legal requirement.

Take great care when using this equipment:

- Be extremely careful when using cutters and welders to repair plant equipment; this includes 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 when blades of slashers, mowers and similar equipment hit rocks or metal, they can cause sparks to ignite dry grass.

[4] NSW Rural fire Service. Farm fire safety. NSW Government, http://www.rfs.nsw.gov.au/dsp_content.cfm?cat_id=1161

- Avoid using machinery during inappropriate weather conditions of high temperatures, low humidity and high wind.
- Do repairs and maintenance in a hazard-free, clean working area such as on bare ground, concrete or in a workshop, rather than in the field.
- Keep machinery clean and as free from fine debris as possible to reduce on-board ignitions. [5]

12.3.2 Steps to preventing header fires

With research showing that, on average, 12 harvesters 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 (Figure 3).

Key points:

- Most harvester fires start in the engine or engine bay.
- Other fires are caused by failed bearings, brakes and electricals, and rock strikes.
- Regular removal of flammable material from the engine bay is urged. [6]

More information

GRDC Media Centre: Harvester fires

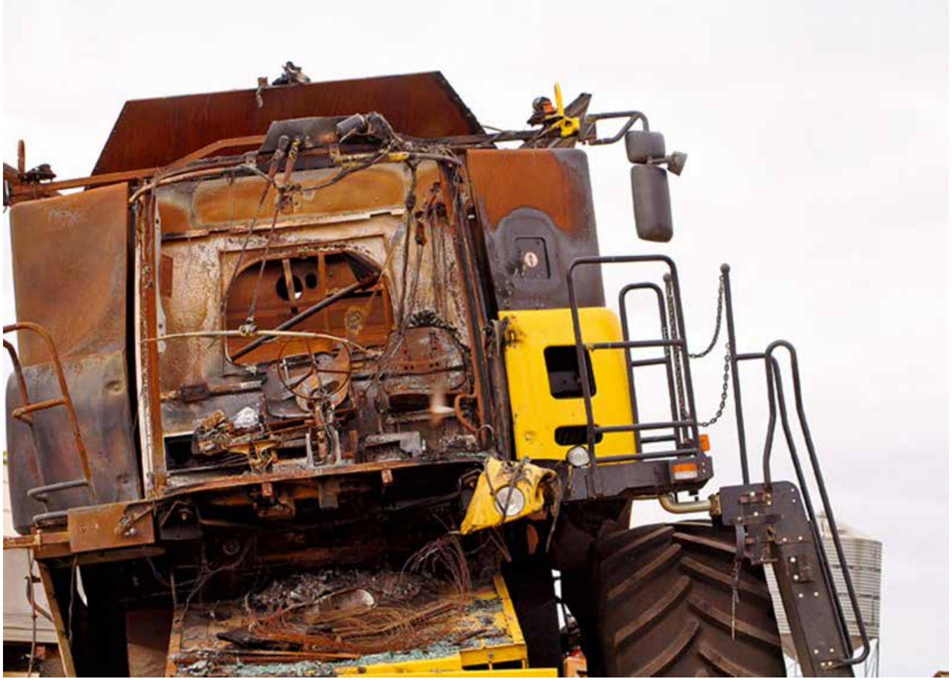

Figure 3: Keeping headers clean can reduce the risk of fire. (Photo: Rebecca Thyer)

12.4 Receival standards

Wheat delivered into the market place must meet certain grain-quality specifications to be classified into the relevant grades. These testing procedures are important benchmarks for end users in determining flour yield and quality for different bread, bakery, pasta and noodle products.

The following grain tests are applied at receival points to measure quality and to ensure that the high standards of Australian wheat grade classification are maintained.

5 NSW Rural fire Service. Farm fire safety. NSW Government, http://www.rfs.nsw.gov.au/dsp_content.cfm?cat_id=1161

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

12.4.1 Protein content

Protein content is one of the important factors influencing the end uses and markets of wheat; consequently, wheat is graded according to protein content. Protein content is assessed by using near-infrared (NIR) technology on delivery at the silo, and payment is based on protein content. Wheat with 11–13% protein is used for pan bread, 10.5% for udon noodles and 8.5–9.5% for biscuits and cakes.

12.4.2 Protein quality

Protein (gluten) quality differs between wheat varieties and so influences the selection of wheat varieties for production applications. For example, bread makers may require a wheat type with strong protein, whereas a manufacturer of steam buns may seek moderate protein strength. For millers, this is an extremely important quality characteristic because it affects flour water absorption and dough mixing characteristics. Protein quality is accounted for at the receival point by variety declaration.

12.4.3 Falling number

The falling number test indicates rain damage at harvest. Rain causes mature wheat grains to sprout and activates the alpha-amylase enzyme, which breaks the starchy endosperm into sugars. In this test, wheat is ground, mixed with water and heated to form a gelatinous suspension. The time taken for a plunger to fall through the suspension is measured. Wheat that has been weather-damaged forms a more viscous suspension and so has a lower falling number. End products are sensitive to flour with low falling number, because it can result in dough stickiness, excessively dark bread, or poor crumb texture and poor slicing ability.

12.4.4 Screenings

Impurities such as white heads, chaff, weed seeds, and shrivelled and broken grains may need to be removed before milling. Payment is based on screening levels, as extensive grading adversely affects mill profit. Although some grain varieties are more susceptible to high levels of screenings, the environment in which the wheat is grown is a major contributor.

12.4.5 Stained grains

Enzymic discoloration such as black point and staining caused by fungal infections (e.g. by *Fusarium*, *Eppicoccum* or *Drechslera* spp.) adversely affect grain quality. In particular, black specks detract from the appearance of noodles.

12.4.6 Hardness

Wheat can be physically hard or soft. Hardness affects milling properties. Hard wheats are used to make pan breads, yellow alkaline noodles and flat breads. Soft wheats are used for biscuits and cakes. Soft wheat flour is much finer than hard wheat flour. Variety declaration is used to segregate hard from soft wheat at receival.

12.4.7 Moisture content

When wheat is delivered into a silo, moisture content is assessed at receival by NIR technology and payment is based on moisture content. Water content affects the value of grain (water *v.* flour) and affects the maintenance of quality during handling and storage.

12.4.8 Test weight

Test weight is also known as 'hectolitre weight' and assessed by weighing a fixed volume of grain. Hectolitre weight informs the miller of the wheat's cleanness, plumpness and packing density, and guides the miller in predicting flour yield. Test weight differs between varieties, owing to their differences in size and shape. Shrivelled and rain-damaged grains reduce test weight.

View the latest grain-receival standards at GrainCorp Ltd Receival Standards: http://www.graincorp.com.au/storage-and-logistics/technical-services/technical-documents-and-information.

The information is in accordance with the Grain Trade Australia (GTA) national grain receival standards. [7]

The GTA Trading Standards are a critical tool for anyone purchasing, selling, trading, broking or operating in the commercial grain industry. The GTA Trading Standards cover all grains, oilseeds, pulses and other related commodities.

12.5 Harvest weed-seed control

Targeting weed seeds at harvest is a pre-emptive action against problematic populations of annual weeds. Our most damaging crop weeds—annual ryegrass, wild radish, wild oats and brome grass—are all capable of establishing large, persistent seedbanks. Thus, if annual weeds are allowed to produce seed that enters the seedbank, the cropping system will inevitably be unsustainable.

More information

GRDC Weed Webinars: Beginners guide to harvest weed seed control

Fortunately, seedbank decline is rapid for these weed species, with annual seed losses of 60–80%. Without inputs, a very large seedbank (>1000 seed/m^2) can therefore be reduced to a very modest one (<100 seed/m^2) in just 4 years. A small seedbank of weeds allows easier and more effective weed control with reduced risk of development of herbicide resistance. Effective weed management in productive cropping systems is thus reliant on preventing viable seed from entering the seedbank. Several systems developed over the past three decades target the weed-seed-bearing chaff fraction during harvest. [8]

12.5.1 Intercepting annual weed seed

In Western Australia, where high frequencies of herbicide-resistant annual weed populations have been driving farming practices for the last decade, techniques targeting weed seeds during harvest have been widely adopted and are now also being rapidly adopted in the southern states. At crop harvest, much of the total seed production for the dominant weed species is retained above harvester cutting height (Table 1). Additionally, for some of these species such as wild radish, high levels of seed retention are maintained over much of the harvest period (Figure 4). 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 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

[7] DPIF Qld (2009) Wheat quality and markets in Queensland. Department of Agriculture and Fisheries, Queensland, http://www.daff.qld.gov.au/__data/assets/pdf_file/0006/53799/Wheat-FactSheet-Quality-Markets-Qld.pdf

[8] M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

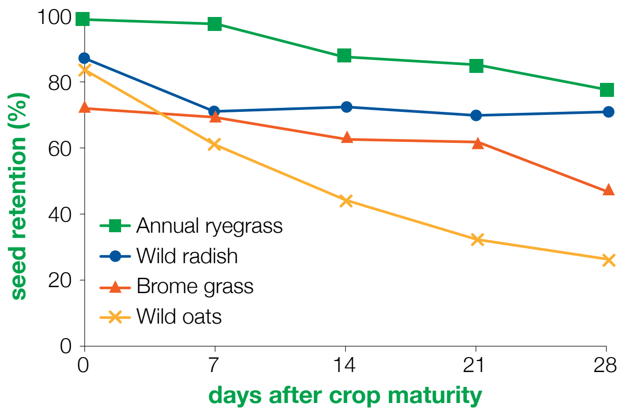

Figure 4: Seed retention above a harvest height of 15 cm over the first 4 weeks of harvest for the major weeds of Western Australian wheat crops.

Lower in-crop weed densities are easier to manage, and their potential development as herbicide-resistant populations is dramatically reduced. Western Australian farmers have driven the development of several systems now available that reduce inputs of annual ryegrass, wild radish, wild oats and brome grass into the seedbank. The adoption of these systems has been critical for the continuation of intensive cropping systems. [9]

More information

IWM Section 4: Tactics

A key strategy for all harvest weed-seed control operations is to maximise the percentage of weed seeds entering the header. This means harvesting as early as possible before weed seed is shed, and harvesting as low as is practical (e.g. 'beer-can' height).

12.5.2 Burning of narrow windrows

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.

Establishing narrow windrows suitable for autumn burning is achieved by attaching chutes to the rear of the harvester to concentrate the straw and chaff residues as they exit the harvester (Figures 5 and 6). 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. [10]

[9] M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

[10] M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

More information

GRDC: Narrow windrow burning in southern New South Wales

GRDC Report: Developments in stubble retention

IWM Section 4: Tactics

GRDC Videos

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

Figure 5: Harvest in action—producing narrow chaff rows for burning in the following autumn. (Photo: A. Storrie)

Figure 6: Windrow burning. (Photo: Penny Heuston)

More information

IWM Section 4: Tactics

GRDC 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

Weed seed bank destruction—seeing results from integrated weed management

12.5.3 Chaff carts

Figure 7: Chaff cart in action at Tarin Rock, WA. (Photo: A. Storrie)

Chaff carts are towed behind headers during harvest to collect the chaff fraction as it exits the harvester (Figure 7).

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. Typically, this material is left in piles in the paddock to be burnt in the following autumn. In some instances though, chaff is removed from the paddock and used as a source of feed for livestock. [11]

12.5.4 Bale-direct systems

An alternative to the *in-situ* burning or grazing of chaff, the bale-direct system uses a 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. [12]

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. [13]

As well as being an effective system for weed-seed removal, the baled material can have a substantial economic value as a feed source. However, as with all baling systems, consideration must be given to nutrient removal. [14]

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

More information

IWM Section 4: Tactics

11 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

12 GRDC. Section 6: Managing weeds at harvest. GRDC Integrated Weed Management Hub, http://grdc.com.au/Resources/IWMhub/Section-6-Managing-weeds-at-harvest

13 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

14 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

GRDC Videos

IWM—Harrington Seed Destructor (3 videos)

Weed seed destruction—beer can height

Weed seed bank destruction—lessons learned—windrowing canola

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

More information

Grassroots Agronomy: Narrow windrow burning in southern NSW

GRDC Fact Sheets: Managing the weed seedbank

GRDC Ground Cover: Harvest systems combined to crush weed-seed resistance

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

12.5.5 Chaff grinding—the Harrington Seed Destructor

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. Because of the importance and potential industry benefits of this process, there has been substantial interest in the development of an effective system.

Ray Harrington, a progressive farmer from Darkan, Western Australia, invented and developed the Harrington Seed Destructor (HSD), a cage-mill-based system attached to the back of the harvester that processes chaff during harvest.

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. [15]

Evaluation under commercial harvest conditions by AHRI has determined that the HSD will destroy ≥95% of annual weed seed during harvest. With the efficacy of the HSD system well established, its development has progressed to commercial production. [16,17]

12.6 Summary

Productive, large-scale conservation cropping as practiced across large areas of the Australian grainbelt is reliant on herbicides for the management of weed populations. This reliance has produced, and continues to produce, widespread occurrence of herbicide-resistant weed populations. Herbicide dependency and resulting loss of effective herbicides is constraining effective grain crop production. Consequently, producers are farming to control weeds instead of for grain crop production. Harvest weed-seed control provides the opportunity to manage weed populations more effectively and to move away from reliance on herbicidal weed control. The consequence is that growers regain flexibility in the overall management of their cropping program. [18]

15 GRDC. Section 6: Managing weeds at harvest. GRDC Integrated Weed Management Hub, http://grdc.com.au/Resources/IWMhub/Section-6-Managing-weeds-at-harvest

16 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers, 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

17 de Bruin Engineering. Harrington Seed Destructor. Projects, De Bruin Engineering, http://www.debruinengineering.com.au/projects/harrington-seed-destructor/

18 M Walsh, S Powles (2012) Harvest weed seed control. GRDC Update Papers 12 April 2012, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

GRDC Update papers

Development of the Harrington Seed Destructor

The nuts and bolts of efficient and effective windrow burning

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

GRDC Videos

GCTV1: Integrated weed control & HSD

GCTV10: Harvester mounted weed destructor

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

IWM—Weed seed capture at harvest (5 videos)

GCTV15: Harvest weed seed control

Weed seed destruction—weed seed management

Weed seed destruction—weed seed capture

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

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