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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

DURUM

SECTION 12

HARVEST

WET HARVEST ISSUES AND MANAGEMENT | DRY HARVEST ISSUES AND MANAGEMENT | FIRE PREVENTION | RECEIVAL STANDARDS | HARVEST WEED SEED MANAGEMENT

Harvest

Key messages:

- Durum is ideally harvested when it reaches a moisture limit of 12.5% but growers with high moisture management facilities can harvest earlier, reducing the risk of weather damage.
- To reduce chaff and whiteheads make sure harvester settings are correct.
- Ensure that harvesting equipment is clean to avoid contamination, and ensure headers are clear to lower the risk of fire.
- Headers need to be blown down with compressed air regularly during harvest to prevent dust buildup around exhaust manifolds and other hot components
- Premiums are paid for high-protein durum grain that is large and undamaged, without mottling, bleaching or contamination.
- Black point-affected durum grain can receive a price reduction
- Concave adjustments might be necessary as durum can be slightly more difficult to thresh than most bread wheats.

Growers should monitor market receival standards and any changes made each year. Harvesting can commence whenever the header is capable of giving a clean grain sample. This is usually when grain moisture is <20% and ideally 12.5% . 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 76 kg/hectolitre (HL), although durum wheat often achieves 80 kg/hL. [1]

Photo 1: *Dryland durum wheat being harvested on 'Keytah' in 2009 using controlled traffic set up harvesters and chaser bins, owned by contractors, on three metre wheel spacings.*

Photo: Kellie Penfold, Source: GRDC

1 DAFQ (2012) Harvesting and yield. Department of Agriculture, Fisheries and Forestry Queensland, September 2012, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/harvesting-information

12.1 Wet harvest issues and management

Ideally, harvest begins as soon as the crop is mature or ripe (Photo 1). 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, a grower with aerated storage could harvest at around 15% MC, while a grower without high moisture management techniques would have to wait until the moisture was <12.5%.

Figure 1 below highlights how harvesting at higher moisture levels can allow an earlier start to harvest, reduce exposure to weather events and result in a shorter total harvest period. The potential harvest period at higher moisture levels spans three weeks (week two to week five) but traditional harvesting, at 12.5% MC, spans four weeks (week three to week seven). The delayed start and longer overall duration when harvesting at traditional moisture levels results in the crop being at risk of potential loss of quality for two extra weeks. For example, significant rainfall event in week five might cause substantial quality loss and hence a significant reduction in the crop's value. [2]

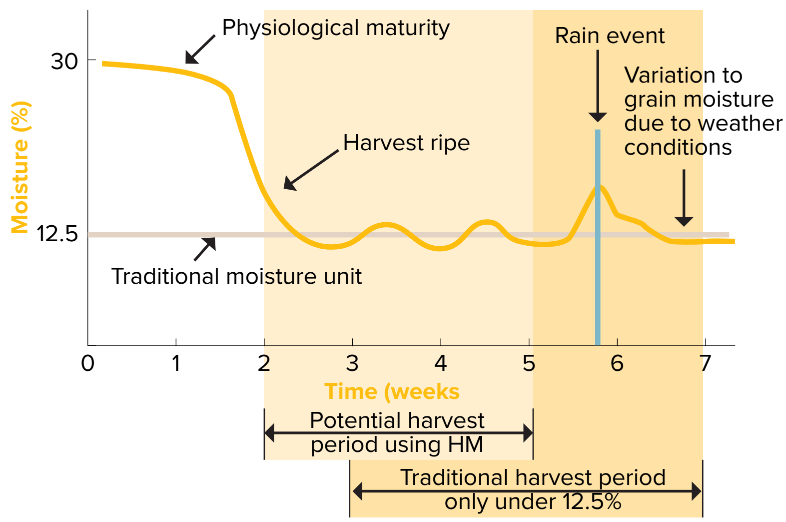

Figure 1: *Grain moisture and harvest period.*

Source: South East Premium Wheatgrowers Association

12.1.1 Delaying harvest

Every day a crop stands in the paddock it is exposed to ongoing yield loss and quality degradation. 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, Western Australia, revealed daily DM losses of 0.18–0.53% DM for wheat and 0.25–0.75% DM for barley (depending on the season and distance from the ocean). [3] Most growers have also experienced some form of grain quality loss due to delayed harvest. For example, if there is

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, Western Australia, http://www.giwa.org.au/_literature_133719/SEPWA_and_CBH_Group_-_the_WA_Guide_to_high_moisture_harvest_management_grain_storage_and_handling

3 MD Bolland, JD Richardson (1984) Time of harvesting barley and wheat near Esperance, Western Australia. Department of Agriculture and Food, Western Australia. Technical Bulletin 66, http://researchlibrary.agric.wa.gov.au/tech_bull/79/

substantial rain, wheat begins to sprout, reducing its flour quality characteristics; and fungal growth reduces the end use possibilities.

These factors can combine to result in heavy discounts, reducing the 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).

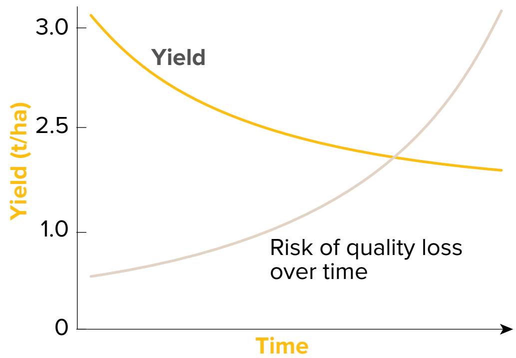

Figure 2: *Crop yield and risk of quality loss over time.*

Source: South East Premium Wheatgrowers Association

12.2 Dry harvest issues and management

The crop should be harvested as soon as the grain reaches maturity to avoid weather damage. Buyers consider grain appearance important and seek large, well-filled vitreous grain with a low percentage of mottled or bleached grains. Header cleaning is also critical to prevent contamination with barley or other cereals. [4]

Premiums are only paid when grain is large and undamaged; not mottled, bleached or—most importantly—contaminated by other grains; and meets all other delivery specifications. Grain harvester machine settings, careful segregation, and clean, insect-free grain storage must receive attention. Damaged, contaminated or insect-infested grain will be downgraded. Durum wheat is a high quality product trading into a high quality food market and attention to detail at harvest is critical. [5]

Concave adjustments might be necessary as durum can be slightly more difficult to thresh than most bread wheats. Take care when adjusting headers, as durum grain has a greater tendency to fracture than bread wheat grain. Some varieties can be prone to shelling, a factor of significance when wind and rain prevail at harvest. All grain should be retained in the head despite these weather conditions. Care needs to be exercised when threshing the crop, due to the grain's tendency to fracture. Buyers of durum grain consider grain appearance important and pay premiums for large, well-filled, hard, vitreous grain with a low percentage of mottled and bleached seeds. [6]

Although durum wheats have slightly better resistance to pre-harvest sprouting than current bread wheats, they may be downgraded to feed due to bleaching and softening of the grain in prolonged wet harvest seasons. [7]

4 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide. NSW Department of Primary Industries Management Guide, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

5 J Kneipp (2008) Durum wheat production. NSW Department of Primary Industries, November 2008, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/280855/Durum-wheat-production-report.pdf

6 R Hare (2006) Agronomy of the durum wheats Kamilaroi⟑, Yallaroi⟑, Wollaroi⟑ and EGA Bellaroi⟑. Primefacts 140. NSW Department of Primary Industries, April 2006, http://www.dpi.nsw.gov.au/content/agriculture/broadacre/winter-crops/winter-cereals/agronomy-durum-wheats

7 DAFQ (2012) Durum wheat in Queensland. Department of Agriculture and Fisheries Queensland, June 2012, http://www.daff.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/durum-wheat

When harvesting severely lodged wheat:

- Try harvesting in different directions to find the angle at which the header best picks up the wheat.
- Adjust the reel slightly ahead of the cutter bar and far enough down to lay the head on the platform.
- The reel should turn slightly faster than ground speed. [8]

Managing wheat residue:

- Wheat straw should be baled or spread uniformly with the combine.
- Leaving heavy amounts of residue on the ground may result in poor seed/soil contact during planting. [9]

12.3 Fire prevention

Grain growers must take precautions during the harvest season, as operating machinery in extreme fire conditions is dangerous. They should take all possible measures 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 combining 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.

Harvester fire reduction checklist

1. Recognise the big four factors that contribute to fires: relative humidity, ambient temperature, wind and crop type and conditions. Stop harvest when the danger is extreme.
2. Focus on service, maintenance and machine hygiene at harvest on the days more hazardous for fire. Follow systematic preparation and prevention procedures.
3. Use every means possible to avoid the accumulation of flammable material on the manifold, turbocharger or the exhaust system. Be aware of side and tailwinds that can disrupt the radiator fan airblast that normally keeps the exhaust area clean.
4. Be on the lookout for places where chaffing can occur, such as fuel lines, battery cables, wiring looms, tyres and drive belts.
5. Avoid overloading electrical circuits. Do not replace a blown fuse with a higher amperage fuse. It is your only protection against wiring damage from shorts and overloading.
6. Periodically check bearings around the harvester front and the machine. Use a hand-held digital heat-measuring gun for temperature diagnostics on bearings and brakes.
7. Maintain fire extinguishers on the harvester and consider adding a water-type extinguisher for residue fires. Keep a well maintained fire fighting unit close-by to the harvesting operation ready to respond.
8. Static will not start a fire but may contribute to dust accumulation. Drag chains or cables may help dissipate electrical charge but are not universally successful in all conditions. There are some machine mounted fire-suppression options on the market.
9. If fitted, use the battery isolation switch when the harvester is parked. Use vermin deterrents in the cab and elsewhere, as vermin chew some types of electrical insulation.
10. Observe the Grassland Fire Danger Index (GFDI) protocol on high fire risk days.

8 DuPont Pioneer (2013) Crop focus: wheat harvest tips. DuPont Pioneer Agronomy Sciences, https://www.pioneer.com/CMRoot/Pioneer/US/Non_Searchable/agronomy/cropfocus_pdf/wheat_harvest_tips.pdf

9 DuPont Pioneer (2013) Crop focus: wheat harvest tips. DuPont Pioneer Agronomy Sciences, https://www.pioneer.com/CMRoot/Pioneer/US/Non_Searchable/agronomy/cropfocus_pdf/wheat_harvest_tips.pdf

11. Maintain two-way or mobile phone contact with base and others and establish a plan with the harvest team to respond to fires if one occurs. [10]

Using machinery

To preventing 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 outdoors:

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, as these components can drop hot metal onto the ground, starting a fire.

Use machinery correctly, as 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.

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, as this can reduce onboard ignitions. [11]

With research showing an average of 12 harvesters burnt to the ground every year in Australia (Photo 2), agricultural engineers encourage care in keeping headers clean to reduce the potential for crop and machinery losses.

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. [12]

Photo 2: *GRDC figures show that there are 1000 combine harvester fires in Australia each year.*

Source: Weekly Times

10 Barr R. (2015). Plant of attack needed for harvester fires. https://grdc.com.au/Media-Centre/Media-News/South/2015/10/Plan-of-attack-needed-for-harvester-fires

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

12 GRDC (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

PODCAST

GRDC Podcasts: Harvester Fires.

MORE INFORMATION

GRDC Reducing Harvester Fire Risk: The Back Pocket Guide

An investigation into harvester fires

Plan of attack needed for harvester fires

12.3.1 Harvesting in low-risk conditions

Growers can use the Grassland Fire Danger Index guide to assess the wind speed at which harvest must cease (a GFDI of 35), depending on the temperature and relative humidity (Figure 3).

Step 1: Read the temperature on the left hand side.

Step 2: Move across to the relative humidity.

Step 3: Read the wind speed at the intersection. In the worked example, the temperature is 35oC and the relative humidity is 10 per cent so the wind speed limit is 26kph.

AVERAGE WIND SPEED (KPH)†

TEMP °C	5	10	15	20	25	30	40	50	60	65	RH%*
15	31	35	38	40	43	45	49	53	56	58	
20	29	33	36	38	40	43	46	50	53	55	
25	27	30	33	36	38	40	44	47	50	52	
30	25	28	31	33	35	37	41	44	47	49	
35	23	26	28	31	33	35	38	41	44	46	
40	21	24	26	28	30	32	35	39	41	43	
45	19	22	24	26	28	30	33	36	39	40	
TEMP °C	5	10	15	20	25	30	40	50	60	65	RH%*

*RH% (Relative Humidity rounded down)
†Wind speed averaged over 10 minutes

Figure 3: *Grassland fire danger index guide.*

Source: CFS South Australia

12.4 Receival standards

Some of the main aspects of grain quality are considered at receival:

1. Protein
2. Test weight
3. Screenings
4. Falling number
5. Black point
6. Weed seed contamination

The hard vitreous kernel (HVK) endosperm section of the grain is the important part, as it is this fraction that is processed into semolina (a coarse flour) and, in turn, mixed with a little water to form a stiff dough under vacuum and extruded under pressure into pasta, forming various shapes—both long and short goods. The endosperm is the food supply or life support system for the developing embryo. The endosperm and embryo are 'wrapped up' in several layers of tissue called the aleurone, pericarp and testa. The embryo and outer grain layers are removed during milling, into the bran and pollard fractions, while the endosperm is reduced to semolina. The endosperm is composed of numerous constituents including starch, sugars, proteins, amino acids, minerals, fats, vitamins, enzymes, pigments and fibre. A large, well-filled grain with bright amber colour and oval shape with minimal crease length is required at receival.

Durum wheat varieties express a satisfactory level of resistance to pre-harvest sprouting compared with current bread wheat varieties. Weather-affected grain is soft, which reduces the semolina extraction in the mill. Weathered semolina gives low pasta-dough strength due to the partial enzymatic breakdown of starches and proteins. These small protein and starch molecules have reduced cohesive properties. Weak doughs make inferior pasta. High-protein durum grain with a bright amber bloom is certain to attract the best available premium price. It is not advisable to leave your durum harvest until last, relying on its weathering resistance. Its resistance is only relative to other varieties and will eventually fail. Weathered durum is not valuable and may be received as feed grain.

Grain with adequate protein is very hard, vitreous and free from mottling. For milling, a small percentage of mottled grains can be tolerated in top grades, but a greater proportion will result in downgrading and a reduced premium. Vitreous grain contains sufficient protein to combine all the starch granules; however, a shortage of protein will give a mottled, softer grain. Protein can be envisaged as the equivalent of cement, which binds the starch granules or the aggregate together. With insufficient cement, the aggregate will not all bind and thus the concrete will be weak and break down readily. The same is the case with mottled sectors in grain. The degree of mottling in individual grains, together with the percentage of mottled grains in the seed lot, both contribute to the 'flour' formation and consequent milling losses. 'Flour' or 'fines' has a lower economic value than that of semolina. Hard, vitreous grains shatter into rough aggregates and produce a high semolina yield.

The canning industry specifies high protein semolina for canned pasta. High protein pasta withstands the high pressure/temperature cooking and retorting processes in acidic tomato pasta. Further, this pasta retains its consistency on warming and serving by the consumer. Dry pasta manufacturers require acceptable levels of protein but not as high as those required by the canning industry. Low protein semolina is unsuitable for pasta making as it has insufficient protein to give the product acceptable keeping, cooking and eating consistency. EGA Bellaroi⦇D⦈ and the varieties Jandaroi⦇D⦈ and Caparoi⦇D⦈, are highly suitable for pasta and couscous production which are regarded by many Italian manufacturers as being equivalent to the best in the world.

The protein content of grain is largely under environmental control. Plants growing in soils with adequate nitrogenous fertility will lay down acceptable protein levels in the grain. The grain protein comprises a large number and complex range of protein types. The proteins range from short molecules to long, folding molecules. The long molecules adhere to each other and form an interlocking network, which prevents the starch and other components from moving freely. The degree of interlocking (chemical bonds) between these long-chained proteins determines the mobility of the pasta dough, which is called the 'dough strength'. Pasta dough strength, or the resistance of the dough to move under work (force), is mainly under genetic control. Cultivars that offer strong to very strong pasta doughs have been released. The dough strength, which is equivalent to protein strength, is a key determinant of pasta quality through its effect on the internal consistency of extruded products. Pastas made from strong protein doughs retain their shape and consistency on cooking and eating. Weaker pastas tend to break down during cooking. Bread wheat pastas are of this undesirable type.

The colour of pasta is a factor in consumer acceptance. Pale to white or brown pastas do not have a pleasing appearance and they are passed over for the bright, clear yellow pasta by the consumer. Only durum wheat can provide this colour without the addition of expensive synthetic pigments or egg products. The addition of artificial colours is banned in Italy and France. Law dictates that durum wheat must be used for dry pasta in these countries. Pasta colour is principally under genetic control; therefore, only highly coloured varieties are released. [13]

12.4.1 Hard vitreous kernel testing

The lack of an objective method for receival testing and binning of durum according to its hard vitreous kernel (HVK) percentage is costing the industry $20 to $40/t in quality claims. Through GRDC support, the Australian Durum Industry Association

13 R Hare (2006) Agronomy of the durum wheats Kamilaroi⦇D⦈, Yallaroi⦇D⦈, Wollaroi⦇D⦈ and EGA Bellaroi⦇D⦈. Primefacts 140. NSW Department of Primary Industries, April 2006, http://www.dpi.nsw.gov.au/content/agriculture/broadacre/winter-crops/winter-cereals/agronomy-durum-wheats

(ADIA) led the push for the development of a new objective HVK measurement based on existing near-infrared technology at the sample stand. A method with acceptable accuracy (plus or minus 4%) has been achieved as a result of collaboration between ADIA, BRI Australia, CSIRO, GrainCorp, ABB Grain, AWB and instrument manufacturer FOSS. The method is now being used to provide HVK testing on durum at delivery points across New South Wales and South Australia. Results are being recorded on weighbridge tickets. [14]

12.5 Harvest weed seed management

An important question needs to be answered: how can harvest weed seed practices be adopted to reduce soil weed seed banks to address herbicide resistance? And more specifically, how can growers get weed seeds into the header? [15]

Trials in both south-eastern and western Australian grain-growing regions have found a 55 to 58 per cent reduction, overall, in the emergence of annual ryegrass across the three main harvest weed-seed control (HWSC) systems being practised by growers. [16]

MORE INFORMATION

IWM manual section on harvest weed management.

IWM manual section on narrow windrow burning.

12.5.1 HWSC Strategies

Weed seed capture and control at harvest can assist other tactics to put the weed seed bank into decline. Up to 95% of annual ryegrass seeds that enter the harvester exit in the chaff fraction. If it can be captured, it can be destroyed or removed.

Western Australian farmers and researchers have developed several systems to effectively reduce the return of annual ryegrass and wild radish seed into the seed-bank, and help put weed populations into decline.

A key strategy for all harvest weed seed control operations is to maximise the percent of weed seeds that enter 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.'

Narrow windrow burning

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.

Windrow burning for weed control

- 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

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14 GRDC (2004) Improving durum quality for market—receival point testing for vitreous kernel. Grains Research and Development Corporation, June 2004, http://finalreports.grdc.com.au/ADI00001

15 Watt S. (2016). Weed seed project aims to keep growers out of the woods. https://grdc.com.au/Media-Centre/Media-News/South/2016/03/Weed-seed-project-aims-to-keep-growers-out-of-the-woods

16 Clarry S. (2015). Trials measure harvest weed-seed control. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-115-MarApr-2015/Trials-measure-harvest-weed-seed-control

MORE INFORMATION

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

[IWM manual section on chaff carts]

[IWM manual section on bale direct systems]

- Growers need to begin experimenting now on small areas to gain the experience needed to successfully implement the strategy. [17]

Narrow windrow burning is extremely effective – destroying up to 99 per cent of annual ryegrass and wild radish seeds – but it must be done properly. For ryegrass, a temperature of 400°C for at least 10 second is needed to destroy the seeds' viability. For wild radish, the temperature needs to be 500°C for at least 10 seconds. [18]

Chaff carts

Chaff carts are towed behind headers during harvest to collect the chaff fraction (Photo 3). Collected piles of chaff are then either burnt the following autumn or used as a source of stock feed.

Photo 3: *Chaff cart in action.*

Photo: A. Storrie

Chaff carts will collect and remove up to 85 per cent of annual ryegrass and wild radish seeds that pass through a header. Collected chaff must be managed to ensure the seeds are then removed from the cropping system. This can be done by burning in the following autumn or by removing the chaff from the paddock and using it as a livestock feed. [19]

Bale direct systems

The bale direct system uses a baler attached to the harvester to collect all chaff and straw material. This system requires a large baler to be attached to the back of the harvester. As well as removing weed seeds, the baled material has an economic value as a livestock feed source. (See http://www.glenvar.com/ for the story and development of header-towed bailing systems).

Harrington Seed Destructor

The HSD is the invention of Ray Harrington, a progressive farmer from Darkan, WA (Photo 4). Developed as a trail behind unit, the HSD system comprises a chaff processing cage mill, 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

17 Street M, Shepherd. (2013). Windrow burning for weed control – WA fad or a viable option for the east? https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Windrow-burning-for-weed-control-WA-fad-or-viable-option-for-the-east

18 Clarry S. (2015). Trials measure harvest weed-seed control. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-115-MarApr-2015/Trials-measure-harvest-weed-seed-control

19 Clarry S. (2015). Trials measure harvest weed-seed control. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-115-MarApr-2015/Trials-measure-harvest-weed-seed-control

MORE INFORMATION

IWM manual section on Harrington seed destructor

VIDEOS

WATCH: Harvest weed seed control for the high rainfall zone.

WATCH: Harvest – the time to get on top of resistant weeds.

WATCH: A beginner's guide to harvest weed seed control.

organic matter to protect the soil from wind and water erosion, as well as reducing evaporation loss when compared with windrow burning, chaff carts and baling. [20]

The HSD, which renders seeds non-viable by collecting and impacting the chaff as it exits the harvester, can be 92 to 99% effective, depending on seed species. [21]

Photo 4: *Harrington seed destructor at work.*

Source: GRDC.

20 GRDC Integrated weed management hub. Section 6: Managing weeds at harvest. https://grdc.com.au/Resources/IWMhub/Section-6-Managing-weeds-at-harvest

21 Clarry S. (2015). Trials measure harvest weed-seed control. https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-115-MarApr-2015/Trials-measure-harvest-weed-seed-control