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CORPORATION

CHICKPEA

SECTION 12

HARVEST

WINDROWING | HARVEST TIMING | HEADER MODIFICATIONS AND SETTINGS | GETTING A CLEAN SAMPLE | FIRE PREVENTION | RECEIVAL STANDARDS | HARVEST WEED SEED MANAGEMENT

Harvest

Key messages

- Greatly improved crop management and harvest timing has meant that chickpea can be harvested earlier with associated yield and marketing benefits. The tradition of delaying the harvest of chickpea until after wheat can result in considerable chickpea losses.
- If harvesting grain for seed, germination rates are improved if grain is harvested at 12–14% and then stored in aerated silos or immediately graded and bagged.
- Early, or timely, harvest of the chickpea crop has the potential to increase returns by up to 50% (Figure 1).
- Clean headers and sowing equipment to remove grain, soil and stubble before moving from property to property to avoid disease and weed spread. Spray rigs should also be cleaned to reduce the risk of disease transmission. [1]
- During harvest, chickpea can produce a dust that is quite flammable, so make sure headers are blown down frequently to avoid a fire risk.

Figure 1: *Chickpea harvest under way.*

Photo: R. Bowman, Seedbed Media

1 DAFWA. Desi Chickpea Essentials. https://www.agric.wa.gov.au/chickpeas/desi-chickpea-essentials

Paddock selection for a happy harvest

Planning before and during sowing can reduce many harvest difficulties. Paddock selection will determine the risk of disease, waterlogging, weeds and poor establishment, ultimately influencing crop maturity. Sowing method and row spacing will affect evenness, crop height and lodging potential. All of these factors can affect the ease and timeliness of harvest. [2]

Agronomist's view

12.1 Windrowing

Windrowing (or swathing) at early or late maturity stages has been found to decrease seed yield, weight per seed and harvest index compared to direct combine practices. Seeds from the windrow treatments have been found to have high percentages of green and shrivelled seeds with high levels of fungal colonisation. Both seed and straw from windrowing have been found to have poor feeding quality measured as neutral detergent fibre, acid detergent fibre, and organic matter content and digestibility. [3]

Windrowing of chickpeas is possible, but not widely used because there is little or no stubble for the windrow to sit on compared with, for example, canola. Losses at harvest may be greater, and more dirt may enter the grain sample. Light windrows can be blown away in strong winds.

Despite this, provided the windrows are large enough and compacted, windrowing is possible. It may also be possible to place two swathes into the one windrow and compact it with a cotton reel roller when windrowing. Harvesting time can therefore be improved.

In chickpeas, windrowing or desiccation can occur when less than 20% of pods are green and 90% of seed is changing from a green colour. The main advantages of windrowing are earlier harvest, reduced seed damage and less shattering or pod loss, particularly if harvest is delayed. Pod loss and shatter are reduced because windrowers allow unhindered passage onto the canvas due to the absence of platform augers. Lower harvesting heights may also be possible. Windrowing helps to dry out green broadleaf weeds, such as radish, which can cause major problems at harvest.

Windrowing also reduces damage to headers. Use of headers in rougher country can damage knife fingers and sections, retractable fingers and other components, because of sticks and stones. Pick-up fronts leave most of these on the ground. The cutting height for windrowing should be just below the bottom pods, with the reel following the top of the crop. The reel speed should be quite slow. The delivery opening in the windrower should be large enough to prevent blockages; otherwise, there will be lumps in the windrow. Windrows should be dense and tightly knit for best results.

Curing should take about 10 hot days. However, heavy infestations of radish and other weeds could delay drying. Pick-up fronts are the most common type used for harvesting windrows. However, crop lifters placed close together on open fronts have been used with some success. [4]

2 DAFF (2012) Chickpea—harvesting and storage. Department of Agriculture, Fisheries and Forestry Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/harvesting-and-storage

3 Y Gan, AD Iwaasa, MR Fernandez, R McVicar (2008) Optimizing harvest schemes to improve yield and feeding quality in chickpea. Canadian Journal of Plant Science, 88(2), 275-284.

4 Pulse Australia Ltd (2013) Northern chickpea best management practices training course manual—2013.

12.2 Harvest timing

Chickpea harvest can often clash with wheat harvest, and traditionally wheat has been given priority due to potential quality premiums. However, this thinking needs to be balanced against the relatively higher value and potential losses that can result from a late chickpea harvest. Agronomists report that many growers consider losses in chickpeas will generally be less than in cereals. However, yield losses increase significantly the longer harvest is delayed.

Chickpeas should be harvested as soon as they mature (Figure 2), as pods will fall if harvest is delayed. [5] Crop desiccation enables even earlier harvest. [6]

Figure 2: *Mature chickpea plant.*

Source: The Land

Harvesting early also minimises infection of seed. Diseases can be transmitted in stubble and soil, and on machinery and boots. Soil and stubble can be moved by machinery, during windy or wet weather, and in floodwater. To reduce the transmission of diseases, clean headers, sowing equipment and spray rigs to remove grain, soil and stubble before moving from property to property. [7]

Harvest timing will depend on the moisture content that is acceptable for delivery or storage. This will depend on who is buying the grain, or whether aeration is available in the storage. Harvesters should be set up to operate efficiently at 14–15% grain MC. This effectively doubles the harvest period available on any one day compared to harvesting at 12%. Research has shown that average harvest losses increased as harvest was delayed (and seed moisture decreased). [8]

The maximum moisture for chickpeas is 14% for grower receivals. Harvesting grain at 13–15% moisture content will help to minimise cracking. Above 14% moisture, the crop should be either aerated or dried. Aeration is usually very effective in reducing chickpea moisture content by several percentage points. [9]

Harvesting at moisture levels below the receival standard of 14% can be costly. Moisture content decreases with late harvest (Table 1). [10] Delaying harvest from 14% MC to 8% MC for a 500 tonne crop equates to a 32 tonne weight reduction, and a

5 GRDC (2008) Harvesting. In Grain Legume Handbook. GRDC, http://www.grdc.com.au/uploads/documents/9%20Harvesting.pdf

6 GRDC (2013) Chickpea disease management (southern and northern regions). Fact sheet. GRDC, http://www.grdc.com.au/Resources/Factsheets/2013/05/Chickpea-disease-management

7 GRDC (2013) Chickpea disease management (southern and northern regions). Fact sheet. GRDC, http://www.grdc.com.au/Resources/Factsheets/2013/05/Chickpea-disease-management

8 B O'Mara, S Belfield, G Cumming (2007) Chickpea harvest and seed storage. Pulse Australia, http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

9 DAF Queensland (2012) Chickpea—harvesting and storage. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/harvesting-and-storage

10 B O'Mara, S Belfield, G Cumming (2007) Chickpea harvest and seed storage. Pulse Australia, http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

loss of $17,500 (at $550/t). This is in addition to any harvest losses that occur due to low moisture at harvesting. Pulse Australia has calculated the economic losses caused by loss of moisture below the Grain Trade Australia (GTA) receival standard of 14% moisture content (MC) maximum.

- 500 t of chickpea at 14% grain moisture, at $450/t, is worth $225,000.
- The same grain harvested at 8% moisture delivers 470 t, at $450/t, and is worth $210,600.
- This is a loss to the grower of $14,400. [11]

Table 1: *Yield and moisture loss with delayed harvest.*

Harvest timing	Average moisture	Harvest loss
On time	12.7	10%
Late	10.3	23%

Source: Pulse Australia

Note: Crops intended for seed are best harvested at 14–16% MC and dried or aerated back to 12% to maximise both germination and vigour when held in storage. [12]

Yield losses of up to 30% have been recorded in the field, due to delayed harvest (Figure 3). Grain losses due to a 2–4 week delay in harvest were estimated at A$93–238/ha, depending on seasonal conditions. In this instance, most of these losses were due to pod loss at the header front, or unthreshed pods discarded out of the back of the machine.

In most years, chickpea yields can average ~70% of wheat yields when sown in an identical situation. The use of specialised headers and separate storage facilities for chickpeas may alleviate the competition with wheat for time, labour and equipment usage.

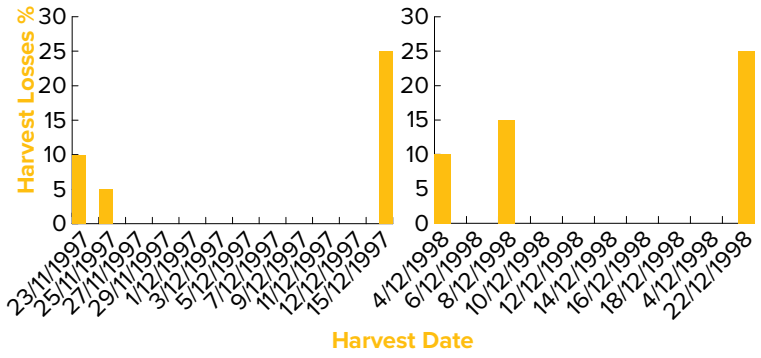


Figure 3: *Harvest yield losses in 1997 (left) and 1998 (right).*

Source: Pulse Australia

Although not normally prone to pod splitting and shelling-out in all but extreme wet-weather conditions, chickpeas are very prone to pod-drop as the plant dries down. Prolonged weathering in the field weakens the hinge attaching the pod to the stalk, thus increasing pod-drop both before and at harvest, and causing drops in yield.

Lodging is increasingly likely the longer chickpeas are left in the field. The risk is higher if the crop is high yielding and has been planted on wide rows of 70–100 cm.

11 Pulse Australia (2013) Northern Chickpea—Best Management Practices Training Course Manual 2013. Pulse Australia.

12 B O'Mara, S Belfield, G Cumming (2007) Chickpea harvest and seed storage. Pulse Australia, http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

Increased storage is helping farmers to manage losses, and in some instances, reduce freight and handling costs where direct transport of grain to the end-user is possible.

NOTE: Crops intended for seed are best harvested at 14-16% moisture and dried or aerated back to 12% moisture to maximise both germination and vigour when held in storage. [13]

12.2.1 Major losses from late harvest include:

Major losses incurred by harvesting chickpeas late include loss of yield, loss of quality, greater likelihood of disease and insect damage to pods and seeds, and loss of markets.

Loss of yield

- Losses due to pod drop can be severe as weathering weakens the hinge attaching the pod to the stem.
- Weathered pods become more difficult to thresh, resulting in grain loss from unthreshed pods passing out the back of the header, increased cracked grains and a slower harvest.
- Increased lodging, especially in higher yielding crops that are planted on wide rows.
- Harvesting at 8% moisture instead of 14% results in a harvest loss.
- Farmer experience has shown yield losses of up to 30% if harvest is delayed 2–4 weeks.

Loss of quality

- Weathered or very dry grain is more likely to crack when handled, increasing the amount of split grain in the sample. Levels of cracked and damaged grain can be as high as 50% in extreme cases of weathering and prolonged rainfall.
- The number of unthreshed pods in the sample will increase, as they become harder to thresh with weathering.
- NOTE: Both of the above can result in rejection or the need for grading to meet market requirements.
- The germination rate and vigour of planting seed will be reduced by weathering.
- Chickpea grain discolours and darkens with weathering, reducing its marketability, particularly in the container market. The following conditions play a major role in accelerating seed coat darkening (Figure 4):
  - » rainfall
  - » cool-mild temperatures
  - » high humidity
- Although there is usually no direct penalty or discount for a moderate degree of seed coat darkening, it does have a significant impact on the marketability of the product and the reputation of the Australian industry as a supplier of quality product. Quality is becoming increasingly important as Australian traders attempt to establish market share against other chickpea-exporting countries (Canada, Turkey, Mexico). We will likely see much greater segregation and premiums paid for lighter coloured, large-seeded Desi types as new varieties with these traits are developed and the Australian industry becomes more quality conscious.

13 Pulse Australia Ltd (2007) Chickpea harvest and seed storage. http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

Figure 4: *Pistol chickpea showing grain discolouration due to weathering.*

Photo: Jenny Wood. Source: NSW DPI

NOTE: Chickpeas that do not meet the Export Receival Standard of 6% maximum 'defective' chickpeas will need to be graded. This incurs a grading cost to the grower of $15–25/t. Downgrading into the stockfeed market results in a value of $120–140/t.

Increased disease and insect risk to pods and seed

- Weathering of seed due to delays in harvest can greatly increase levels of mould infections. High levels of mould infection will also cause darkening of the seed coat.
- Humid (>70% relative humidity), wet conditions favour the development of a range of fungi in late-harvested chickpea crops. *Alternaria spp.* usually predominate, species of Asperguillus, Cladosporium and Penicillium may also be present.
- There is increased risk of late infection by the Ascochyta blight fungus on pods. Ascochyta can infect senescing pods under wet conditions, leading to infected and discoloured seed (and possible rejection). The current Export Receival Standard for visible Ascochyta blight lesions is a maximum of 1% on the seed cotyledon (kernel).
- Native budworm (*Helicoverpa punctigera*) can cause damage to mature seeds. Larvae can occasionally attack senescing chickpeas, particularly where rainfall has softened the pod. Insect-damaged seeds are classified as defective chickpeas, and they cannot exceed the tolerance level of 6%.

Lost marketing opportunities

- Chickpea prices can reach peaks during harvest to meet shipping schedules. Earlier harvesting may allow access to these opportunities.

- Early harvest gives the grower some control over how and when the crop is marketed, whereas late-harvested chickpeas can be 'price-takers' in a falling market.
- Darker, weathered seed may be discriminated against in the market.

Harvest delays in chickpeas cost growers and the pulse industry a lot of money. In any production area, a spread of up to 4–6 weeks can occur in the harvesting of chickpea crops planted on the same sowing rain. Many of the late-harvested crops often have moisture content down to ~8%, whereas the maximum moisture content for receival is 14% and the preference is for 12%. [14]

12.2.2 Planning for early harvest

Early, or timely, harvest of the chickpea crop has the potential to increase returns by up to 50%. Management to ensure even crop maturity and timely harvest consists of a combination of factors including:

- paddock selection and agronomy
- disease and insect control
- desiccation
- harvest timing and technique
- handling and storage [15]

A range of management components contributes to an early crop. They can all be important at different times and for different reasons. It is important to understand the potential and limitations of each management component. Optimal results in terms of yield, profit and earliness will be due to these components being applied in the most appropriate and balanced way, and as dictated by seasonal conditions. These components include:

1. Planting
- Sow at the earliest opportunity within the preferred planting window for your area. Moisture-seeking equipment and/or press wheels can significantly enhance seeding opportunities under marginal conditions.
- Select adapted varieties that meet your target for early harvesting.
- Using precision planters will often achieve more uniform plant establishment and crop development and, consequently, more even crop maturity. Precision planters are not widely used in the south and west but there is growing interest in them.

2. In-crop management
- Control Botrytis grey mould if present during flowering.
- Control native budworm during flowering to maximise early pod set.
- Avoid using herbicides that delay crop maturity, such as flumetsulam (e.g. Broadstrike®).

3. Harvest management
- Consider using Roundup UltraMAX® and Ally® (or equivalent registered products) to terminate the crop at 80–90% yellow–brown pod stage.
- Set the header up to operate efficiently at 14–15% grain moisture content.
- A major advantage of high-moisture harvesting is that harvest can commence earlier in the season and earlier each day.
- Harvesting at 14% moisture content, compared with 12%, can effectively double the harvest period available on any one day.
- Blend, aerate and/or dry the sample to the required receival standard of 14% moisture. [16]

14 Pulse Australia Ltd (2013) Northern chickpea best management practices training course—2013.

15 Pulse Australia Ltd (2007) Chickpea harvest and seed storage. http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

16 Pulse Australia Ltd (2013) Northern chickpea best management practices training course manual—2013.

12.3 Header modifications and settings

Early harvesting means that plants can be easier to gather because they stand more erect, allowing the harvester front to operate at a greater height which reduces the risk of soil, rock and sticks entering the harvester. Early harvesting also means there are fewer summer weeds to clog the harvester. Grain loss can be reduced by harvesting in high humidity—at night if necessary—to minimise pod shattering. Avoid reaping in extreme heat. [17] Chickpeas can be harvested with minor adjustments and modifications to equipment. Open-front or pick-up fronts are best suited to the job. Pulses are easily threshed, so concave clearances should be opened and the drum speed reduced. The crop varies in height from 15–80 cm, with pods held up in the canopy, so direct heading without crop lifters is possible with open-front and closed-front machines. Some fingers may have to be removed when using closed-front machines. Chickpeas thresh easily but are prone to cracking, particularly Kabuli types, so adjust thresher speed (400–600 rpm) and concave (10–30 mm) to suit (Table 2). Because chickpeas are destined for human consumption, a good sample off the header is usually required. [18]

Table 2: *Harvester settings for pulses.*

Reel speed	Spiral clearance	Thresher speed	Concave clearance	Fan speed	Top sieve	Bottom sieve	Rotor speed
Medium	High	400–600 rpm	10-30 mm	High	32 mm	16 mm	700–900 rpm

Source: Grain Legume Handbook

A straw chopper may be of value to chop up the stubble and spread it uniformly. Crop lifters are not usually required unless the crop is badly lodged. Set the finger-tine reel to force the chickpea material down onto the front. Moving the broad elevator auger forward can improve the feeding of light chickpea material. Vibration from cutter-bar action, plant-on-plant or reel-on-crop impact, and poor removal of cut material by the auger all cause shattering and grain loss. Finger reels are less aggressive than bat reels and cause fewer pod losses. Double-acting cutter-bars reduce cutter-bar vibration losses. Four-finger guards with open second fingers also reduce vibrations (Figure 5). [19]

Figure 5: *Finger guard.*

Source: Grain Legume Handbook

17 Pulse Australia Ltd (2013) Northern chickpea best management practices training course manual—2013.

18 GRDC (2008) Grain Legume Handbook.

19 Pulse Australia Ltd (2013) Northern chickpea best management practices training course manual—2013.

Options to improve harvest:

- Vibra-mat. A vinyl mat that vibrates with the knife, stops bunching at the knife of open-front headers and helps the table auger to clear-cut materials. This device is very cheap. It is more effective in light crops. It is important to match ground speed to table auger capacity and crop density: too slow and the plants will not have enough momentum to carry to the front; too fast and the cut crop will not be cleared from behind the knife.
- Extension fingers. (Figure 6) Plastic extension fingers ~30 cm long that fit over existing fingers can save significant losses, for little financial outlay, at the knife. Pods that would have fallen in front of the knife are caught on the fingers and pushed into the comb by the incoming crop.
- Extended fronts. Now available for some headers. They reduce losses at the knife by increasing the distance between the knife and auger to a maximum of 760 mm. This helps to stop material bunching in front of the auger, where pods can fall over the knife and be lost.
- Platform sweeps. Used in conjunction with extended fronts. They consist of fingers that rake material towards the auger to help eliminate bunching. They can also be used on conventional fronts.

Note that cost benefits must be assessed; a small area of pulses may not justify the cost of some of the above modifications. [20]

Figure 6: *Plastic extension fingers fitted to a draper front.*

Photos: G. Cumming, Pulse Australia

12.3.1 Draper Fronts

Draper fronts (i.e. MacDon or Honeybee) have become increasingly popular. The centre feed draper platform provides uniform crop flow into the header, with minimal crop loss, and little damage to the seed. The cutter bar design allows for both vertical and end table flotation. While their contour following ability is not quite as good as a floating cutter bar, they have performed very well, provided the paddock is relatively level. Operators claim they can be operated at higher travel speeds than a conventional front in chickpea.

12.3.2 Preferred Air Front Setups

Air fronts help to reduce shattering losses, and minimise the amount of soil and other debris (stubble, sticks) in the final sample. Where soil contamination is likely to be a problem, fit perforated screens to replace the feeder-house floor and elevator doors, and clean the grain cross augers. Twin blowers may be necessary on fronts wider than 7.6 m. [21]

- Harvest-Aire or other air fronts are generally considered better than batt reels as they minimise the risk of pods detaching from the plant.

20 Grain Legume Handbook Committee (2008) 'Grain legume handbook.' Supported by the Grains Research and Development Corporation (GRDC), https://grdc.com.au/uploads/documents/Index.pdf

21 DAFF (2012) Chickpea—harvesting and storage. Department of Agriculture, Fisheries and Forestry Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/harvesting-and-storage

- They also improve feed in over the knife section, and reduce soil and stubble contamination and allow the operator a clearer view of the cutting platform, and any rocks or sticks in the paddock. Adjustment of the angle and height of the air nozzles is critical, and may need adjustment as crop conditions change.
- Fit a Vibra-Mat to improve the flow of material over the knife-section and along the platform. They are relatively cheap with a low maintenance cost.
- Fit cast, short crop fingers. If using a closed front the fingers will need to be spaced 19 mm or more apart.
- Fitting double density Kwik-cut knife guards will help reduce plant 'vibration' and the risk of pods detaching from the plant. This method may be unsuitable if there are a lot of green weeds in crops that are not desiccated causing blockages.
- Check that the header front is level, and not higher at one end than the other. Set the knife at the correct angle for short crops, and install a simple depth gauge.
- In crops with a short height to lowest pod, soil contamination is likely to be a problem, so it is advisable to fit perforated screens under the platform auger and/or broad elevator. Fit screens to repeat and clean-grain cross augers.
- Floating or flexible cutter bars can be useful in short crops.

12.3.3 Conventional Headers

- Aim to harvest at 300–500 rpm where possible to minimise cracking. Adjust upwards if 'jamming' occurs in crops that are not desiccated.
- Concave clearance 10–30 mm depending on seed size. Check the concave for uneven clearance. Standard concaves tend to bow in the centre when fully loaded, and may need strengthening or replacement (i.e. with a 'Loewen' concave). Removing alternate wires and the blank-off plates from the concave will also help reduce cracking. If possible cover the rasp bars with plate.
- Beater: Reduce speed to 100% of drum speed. Wheat is usually set at 150%.
- Set fan speed at 80–100% of maximum. The relatively heavy weight of individual chickpea grains allows the use of high air flow. [22]

12.3.4 Sieves

An alternative to the barley sieve is a mesh sieve made using 18 mm tubing for the frame and 1 cm by 1 cm, 14-gauge wire mesh. This screen increases capacity because the whole area is able to sieve. If there are summer weeds, the rake at the back of the sieves should be blanked-off to stop them entering the returns. Summer weeds may cause walkers and sieves to block completely, causing high grain loss. [23]

Set sieves to suit the grain size of the chickpea being harvested. This is more critical than for wheat:

- Top sieve 20–25 mm—a B & D Airfoil non-adjustable top sieve is reported to work well in chickpeas, and increases overall sieving capacity.
- Bottom sieve 12–16 mm—the bottom sieves can be altered so that the front 400 mm can be adjusted separately to the rear section. This allows the front section to be left open, and more air can be directed onto the top sieve if required.

12.3.5 Header Speeds

Relatively slow ground speeds are considered essential when harvesting chickpea to minimise excessive losses at the front of the header and the amount of dirt entering the machine.

- A maximum speed of 8 km per hour is recommended.

22 Pulse Australia Ltd (2007) Chickpea harvest and seed storage. http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

23 Pulse Australia Ltd (2013) Northern chickpea best management practices training course manual—2013.

- If using a batt reel, it should be set at the same speed as the header. [24]

12.4 Getting a clean sample

Harvesting of chickpeas can be costly if stones, sticks or too much soil are picked up with the chickpeas. Machinery damage can be reduced by a variety of practices.

12.4.1 Perforated screens

Perforated screens fitted on the bottom of the broad elevator, cross augers, grain and seconds elevators all reduce the amount of soil in the sample. The perforated screen at the broad elevator is large and removes soil before it enters the main working mechanism of the harvester.

12.4.2 Harvester speed

Excessive harvester speeds will cause large losses of grain and force more soil into the harvester. Generally, speeds >8 km/h are not recommended, irrespective of the type of harvester front used.

12.4.3 Harvesting in high humidity

Harvesting in humid conditions, when pods are less prone to shatter, can reduce grain losses. However, more unthreshed pods may appear in the grain sample. It is unwise to harvest peas at night unless using a pick-up front or some positive height control, which will stop the front from digging into the soil. Some farmers have fitted wheels on the outer end of their fronts as a depth stop. Others have purchased ultrasonic automatic depth controls to control header height.

12.4.4 Pick-up fronts

Pick-up fronts that are the same as, or similar to, those used for picking up windrows can be used to harvest windrowed chickpeas. Pick-up fronts greatly reduce the amount of soil entering the harvester and make harvesting easier because harvesting height is not as critical as with a front fitted with lifters. This allows harvesting at night. The fingers on the pick-ups are closely spaced and they will gather the entire crop, so crop losses are reduced.

There are different types of pick-ups. Some have fingers attached to rotating belts (draper pick-ups) and others have fingers attached to rotating drums (peg-roller pick-ups). The pegroller types are similar and cheap but tend to shatter pods and cause slightly higher grain losses than the draper type. The draper types are more expensive but will reduce losses if harvesting late.

12.4.5 Flexible cutter-bar fronts (flexi-fronts)

The cutter-bars of these fronts are hinged in short sections, allowing the whole front to flex and closely follow the ground contour. They use skid plates and are particularly good for short crops such as lentils and peas, but can also be used on cereals by locking the hinged sections together. [25]

12.4.6 Lodged crops

If the crop has lodged, the best option is usually to harvest directly into, or at right angles to, the direction the crop has fallen. If on wide rows, use crop lifters and harvest up and back in the rows. The crop usually feeds in better over the knife

24 Pulse Australia Ltd (2007) Chickpea harvest and seed storage. http://www.pulseaus.com.au/storage/app/media/crops/2007_Chickpea-Harvest-Storage.pdf

25 Grain Legume Handbook Committee (2008) 'Grain legume handbook.' Supported by the Grains Research and Development Corporation (GRDC), https://grdc.com.au/uploads/documents/Index.pdf

section, and also provides the header operator with a better view of any rocks or sticks in the paddock. [26]

12.5 Fire prevention

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.
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. [27]

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.

26 Pulse Australia Ltd (2013) Northern chickpea best management practices training course manual—2013.

27 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

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 on board ignitions. [28]

With research showing an average of 12 harvesters burnt to the ground every year in Australia (Figure 7), agricultural engineers encourage care in keeping headers clean to reduce the potential for crop and machinery losses.

Key findings:

- Most harvester fires start in the engine or engine bay.
- Other fires are caused by failed bearings, brakes and electricals, and rock strikes. [29]

Figure 7: *GRDC figures show that there are 1000 combine harvester fires in Australia each year.*

Source: Weekly Times

12.5.1 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 8).

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 35°C and the relative humidity is 10% so the wind speed limit is 26kph.

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

29 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

MORE INFORMATION

Standards and charts to check visual quality of desi chickpeas are available from Pulse Australia

Australian Pulse Standards 2016–2017

Desi chickpea sample chart of visual standards

TEMP °C	5	10	15	20	25	30	40	50	60	65	RH%*
15	31	35	38	40	43	45	49	53	56	58	AVERAGE WIND SPEED (KPH)
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%*

1 2 3

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

Figure 8: *Grassland fire danger index guide.*

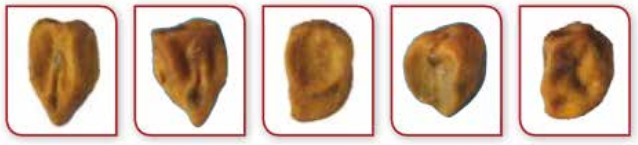
Source: CFS South Australia

12.6 Receival standards

National receival standards for chickpea are set by the pulse industry and maintained by Pulse Australia. Receival and export standards reflect the market requirements for a quality food product. Desi chickpeas should be sound, dry, fresh and light to medium brown in colour, although a greenish tinge is allowed (see Tables 3 and 4). Kabuli chickpeas should be sound, dry, fresh and cream to light brown in colour.

Failure to achieve these receival standards may mean price discounts, re-cleaning or, if severe, market rejection.

Table 3: *Example of visual charts designed to be used as a guide in conjunction with the current Australian Pulse Trading Standards.*

Defect	Visual examples of defective chickpeas
Frost damaged, shrivelled and wrinkled	
Broken, chipped, loose seed coat, and split.	
Insect damaged, and sprouted.	
Hail damaged	

Source: Pulse Australia

Definitions:

- *Defective grains:* includes max 2% field peas (in Desi), 2% poor coloured grains, broken, damaged and split, shrivelled, distorted, grub eaten, sprouted and affected by mould in the paddock.
- *Poor colour:* if cotyledon is distinctly blemished and/or off colour from the characteristic yellow colour of the predominate class, including the 1% visible Ascochyta.
- *Foreign material:* includes unmillable material and all foreign vegetable matter (includes cereals, wild oats, oilseeds, other legumes and weed seeds not otherwise specified).
- *Unmillable material:* includes soil, stones, metal and non-vegetable matter.

Table 4: *Receival standards for Desi and Kabuli chickpea.*

Chickpea type	Max. moisture content (%)	Min. purity (%)	Max. defective & poor colour	Screen size for defective seeds (mm)	Poor colour max. (%)	Foreign material max. in total (%)	Unmillable material max.	Snails max.	Insects max.
Desi	14	97	6	3.95 slotted	2% (but 1% Ascochyta)	3	0.5 (0.3% soil)	1 per 200 g	15 per 200 g
Kabuli	14	97	3	6 round	2% (but 1% Ascochyta)	3	0.5 (0.3% soil)	2 per 400 g	30 per 400 g

Source: Pulse Australia

Individual commodity traders are responsible for ensuring that specific country requirements and those pertaining to compliance with the Export Control Act (1982) are included as additional specifications on the contract.

12.7 Harvest weed seed management

Targeting weed seed has been identified as a key strategy in controlling resistant annual weed populations. The control of these populations is a numbers game and weed seed removal is an excellent strategy that can be used to keep the numbers low. A number of techniques can be used to destroy/remove at least 50% of weed seeds of annual ryegrass and wild radish populations at harvest. Computer modelling suggests that 50% seed removal at harvest will not fix a weed control system that is not working. It will, however, have a significant impact where a weed seed bank is being maintained or increasing slowly.

Trials in both south-western and eastern Australian grain growing regions have found a 55-58% reduction, overall, in the emergence of annual ryegrass across the three main harvest weed-seed control (HWSC) systems being practised by growers. [30]

Research has demonstrated that for a continuous cropping system where only 90% ryegrass control is achieved each year the seed bank of the ryegrass increases slowly over a ten-year period (Figure 9). By adding a chaff cart or baler at harvest that removes 50% and 75% of the ryegrass seeds in the paddock each year respectively, the ryegrass seed bank is eroded over time. Our aim for managing resistant weeds should simply be to continually reduce weed seed banks. Removing weed seeds at harvest is probably the most important non-herbicide weed management tool to achieve this. [31]

30 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

31 DAFWA (2014) Factsheet—Harvest weed seed management. Weed seeds at harvest—spread, catch, divert, burn or destroy?

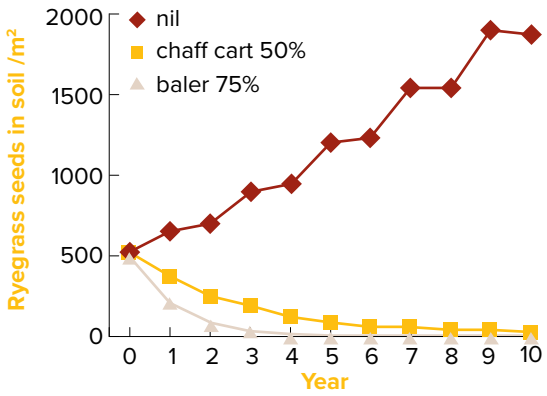


Figure 9: *Computer simulation using RIM program showing the predicted ryegrass seed bank (seeds/m^2) in a pulse-wheat rotation where 90% weed control is achieved each year for three harvest options; Nil (conventional harvest), Chaff cart removing 50% of weed seeds in each crop, or a baler towed behind the header removing 75% of the weed seeds in each crop.*

Source: DAFWA

Weed seed removal can be achieved in two ways:

- Harvesting provides an excellent opportunity to remove weed seeds from the system and prevent them from being spread across the paddock or farm. Collecting seed at harvest has the potential to be a useful component of an integrated weed management program.
- Grazing weed contaminated crop residue can be a cost-effective way of controlling weed growth. Animal digestion of weed seeds prevents a large proportion of seeds from entering the seedbank.

Weed seed collection at harvest will not increase grain yield, as the weeds have already caused damage to the crop. This tactic can only prevent increases to the seedbank, although it may give a subsequent yield advantage to the next season's crop through reduced weed numbers during the season.

12.7.1 Factors affecting weed seed removal

The weed species has a major influence on the proportion of weed seed removed from the paddock when collected at harvest. For example, annual ryegrass is much more available to collect than wild oats, which tend to shed seed before harvest. Successful collection and control depends on the weed:

- maturing at the same time, or later than, the crop being harvested;
- having seeds at a similar or greater height compared with the crop being harvested (this may be overcome by setting the header at a height so that weed seeds are captured);
- having seeds that do not shed or shatter before or during harvest; and
- having seeds that can be threshed and are of a size that end up in the chaff component of the harvested crop.

Timing of harvest will affect the amount of seed removed from the paddock when residue is collected. As harvest is delayed, a greater proportion of the weeds presented will shatter or lodge, reducing the total proportion of seed able to be collected. [32]

32 DAFWA. Crop weed: Weed management at harvest. https://www.agric.wa.gov.au/grains-research-development/crop-weeds-weed-management-harvest

12.7.2 Strategies for weed seed removal at harvest

Chaff carts/Harrington Destructor/Diversion onto tramlines should be able to remove 70–80% of the ryegrass and wild radish that enters the harvester. However, due to ryegrass shedding or lodging this represents approximately 50% of the total weed seeds in the paddock.

The baler and windrow burning should be able to remove 95% of ryegrass and wild radish that enters the front of the harvester. This represents approximately 70% of weed seeds in the paddock (Table 5). [33]

Table 5: *A comparison of the various methods for weed seed collection and management at harvest.*

Tool	Set up cost	Pros	Cons
Windrow burning	$100 to $500	Cheap to get into. No loss of harvest efficiency. Very effective.	Involves burning. Wind erosion risk. Difficult in some cereals. Time consuming in autumn. Nutrient banding.
Chaff cart	$30,000 to $50,000	Minimises area of paddock burnt. Can provide feed source for livestock.	Reduces harvest efficiency. Cost. Burning heaps in autumn is very time consuming.
Chaff diversion onto tramlines	$400 to $5,000	Cheap. No burning. No loss of harvest efficiency. Reduces dust during summer spraying.	Must have fully matched tramline system. Unproven. High weed density on tramlines.
Harrington Destructor	Approx. $100,000	No burning. Nothing to do after harvest. Very robust machine—can handle house bricks!	Cost. Extra piece of machinery.
Baling everything—Glenvar system	$150,000 to $200,000	No burning. Additional income from bales. Most effective tool on the market.	Cost. Extra nutritional drain on soil. Need a market for bales. Handling of lots of bales.

Source: DAFWA

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

33 DAFWA (2014) Factsheet—Harvest weed seed management. Weed seeds at harvest—spread, catch, divert, burn or destroy?

- 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
- Windrow burning is an effective weed management strategy, even in the absence of resistance. [34]

Narrow windrow burning is extremely effective—destroying up to 99% 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. [35]

MORE INFORMATION

IWM manual section on narrow windrow burning

Chaff Carts

Chaff carts are towed behind headers during harvest to collect the chaff fraction (Figure 10). Collected piles of chaff are then either burnt the following autumn or used as a source of stock feed.

Figure 10: *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. [36]

MORE INFORMATION

IWM manual section on chaff carts

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).

MORE INFORMATION

IWM manual section on bale direct systems

34 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

35 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

36 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

Integrated Harrington Seed Destructor

The iHSD is the invention of Ray Harrington, a progressive farmer from Darkan, WA (Figure 11). Developed as a trail behind unit, the iHSD 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 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. [37]

The iHSD, which renders seeds non-viable by collecting and impacting the chaff as it exits the harvester, can be 92-99% effective, depending on seed species. [38]

Figure 11: *Harrington seed destructor at work.*

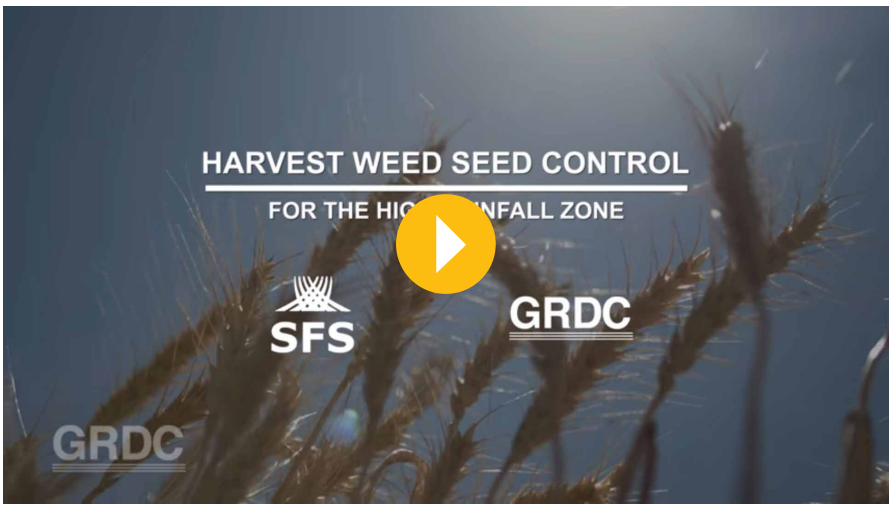
Source: GRDC.

MORE INFORMATION

Managing weeds at harvest

IWM manual section on Harrington seed destructor

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



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

38 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

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

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