The Rice Harvesters REFERENCE

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RIRDC Rice Research and Development Program. RIRDC Publication No. 99/38.

RIRDC

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The Australian Rice Industry

The Australian Rice Industry produces around 1,400,000 tonnes of paddy annually in the Murrumbidgee and Murray Valley irrigation regions of South Western NSW and Northern Victoria in a rice farming system based on world's best management practice to maximise production efficiency and minimise environmental impacts.

Ricegrowers' Co-operative Limited — a grower owned Co-operative — processes 99% of the Australian rice crop and markets high quality rice food products to over 50 export destinations and to domestic consumers.

The Ricegrowers' Association of Australia represents the interests of rice growers to their Co-operative, the Government and the community.

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Kondinin Group research engineers testing rice harvesters near Blighty, New South Wales in 1996.

In 1998, 2300 Australian rice growers produced over 1.3 million tonnes of rice as part of a growing industry worth about $A 600 million annually.

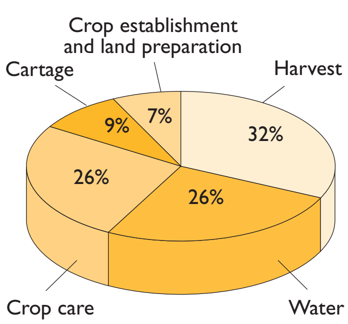
Australian growers also produce the highest average yields in the world; production in 1998 averaged 9.4 tonnes per hectare.

Harvesting rice is the most expensive field activity (see Figure 1). The timing, duration and mode of conduct of the harvest have a direct bearing on rice quality, efficiency, and on growers' incomes (see Figure 1). A delayed or protracted harvest often will downgrade the whole grain mill appraisal.

Rice has its greatest value as whole grain, unlike other crops that are ground or processed before sale.

Maximum whole grain is affected by the season and timing of harvest, see Figure 2. An efficient harvest depends greatly on pre-harvest management — variety selection, timing of establishment, crop care, water and nutrient management and drain-off.

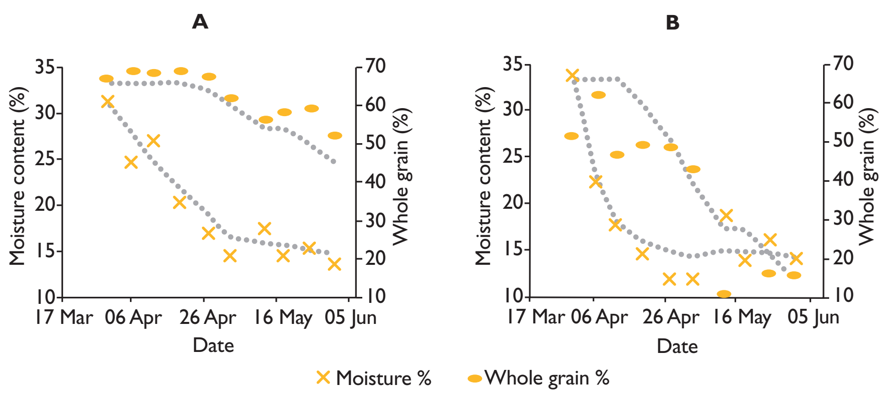
FIGURE 1 Crop production costs



Total cost was $692/ha for this sod-sown medium grain, Amaroo yielding 9.5 t/ha.

Source: NSW Agriculture

FIGURE 2 Effects of time in the season on grain moisture and whole grain



A crop drained on time and in moderate weather (left) and a crop drained too early (right). Note the severe fall in whole grain at millout. (Source : Williams et al, Improving Percentage Whole Grain Millout. *Farmers Newsletter* 145, June 1995).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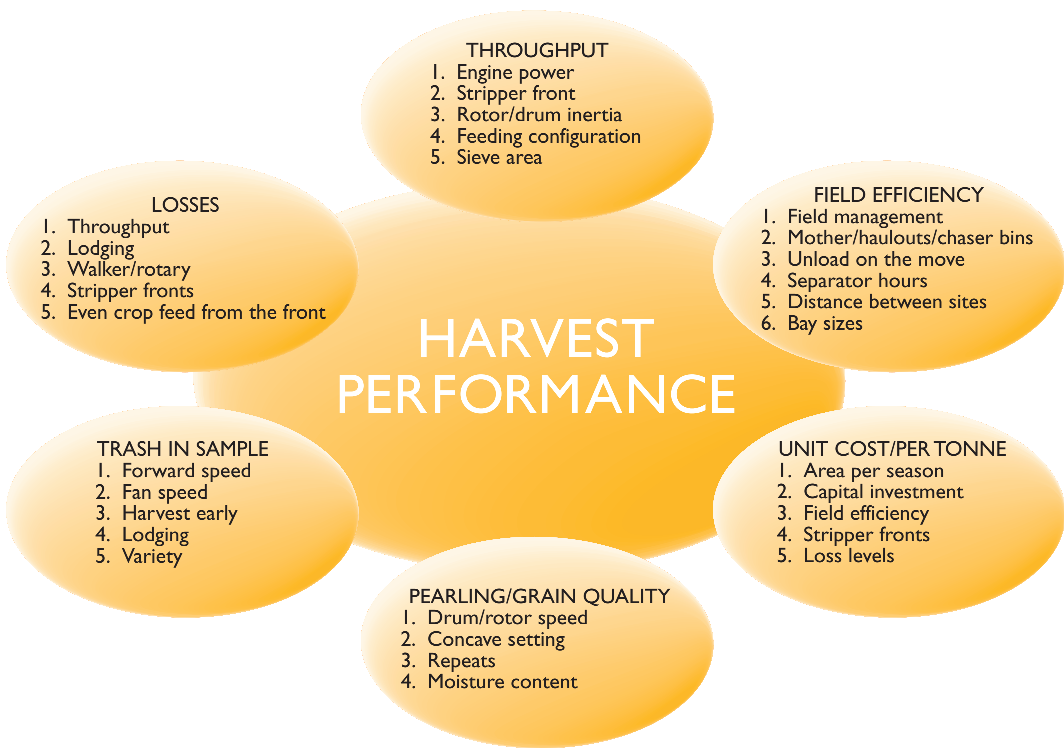
Harvesting is the most expensive component of rice production. Paying careful attention to harvest timing and harvester setup wil minimise losses for maximum gain.

FIGURE 3 Factors governing harvest performance



The sales turnover for rice harvesting machinery is about $6 million a year. Some surveys have indicated the average age of a harvester in Australia to be 9–10 years old.

Rice harvesters in Australia are all imported, so very little can be done locally to change designs. But there are some harvester combinations and attachments available that work better than others.

Types of rice combine harvesters

There are several reasons why a rice crop requires its own harvesting equipment.

Machine flotation

Heavy ground conditions and soft fields require harvesters to be built with high underframe clearances. Traction and flotation aids such as 'rice' tyres, half-tracks, or full crawler ground drive are used, and often grain transporting equipment has to be parked on firm ground outside the paddocks or the bays. Rear wheel assist drive axles are standard on contractor's rice harvesters.

Crop and field conditions

When harvested, the straw is still at a much higher moisture content than the grain. A typical crop has a straw moisture level of 50 to 70 per cent, wet basis, and paddy or rough rice moisture level of 14 to 27%, wet basis.

MOG–grain ratio

The volume of straw, or material other than grain (MOG) taken in by a harvester equipped with a cutterbar is higher for paddy than for other cereals.

The weight ratio for paddy is 1.5 tonnes of MOG per tonne of paddy, compared with 0.8 to one tonne of MOG per tonne of wheat. If the paddy is lodged, and it often is in patches, then the MOG-grain ratio taken into the harvester increases to three or sometimes four to one. A stripper-equipped harvester on the other hand will take in far less straw under good conditions.

A special cylinder or rotor is usually a necessity for rice harvesting. Tangential flow harvesters are equipped with a spike-tooth cylinder and concave, installed in place of the rasp-bar type of drum. On axial harvesters a specialty rotor is fitted for rice.

The spike-tooth thresher may also be used for other crops, but has limitations in more difficult seasons or conditions such as removing whiteheads in wheat.

Component wear

Rice straw and paddy is highly abrasive. Rough rice is tightly encased in layers of husk that are protective, but high in silicaceous materials which are compounds similar to the key ingredient of sandpaper. For example, ash is 70% silicon and rice straw is also high in silica.

Harvester models have to be modified for rice fields with selected components made from stainless steel, other alloys or hardfacing treatments to resist abrasion better. The components affected most often include auger flighting, auger troughs, elevator housings, thresher bars, auger troughs and occasionally special knife sections for cutterbars.

Lodging

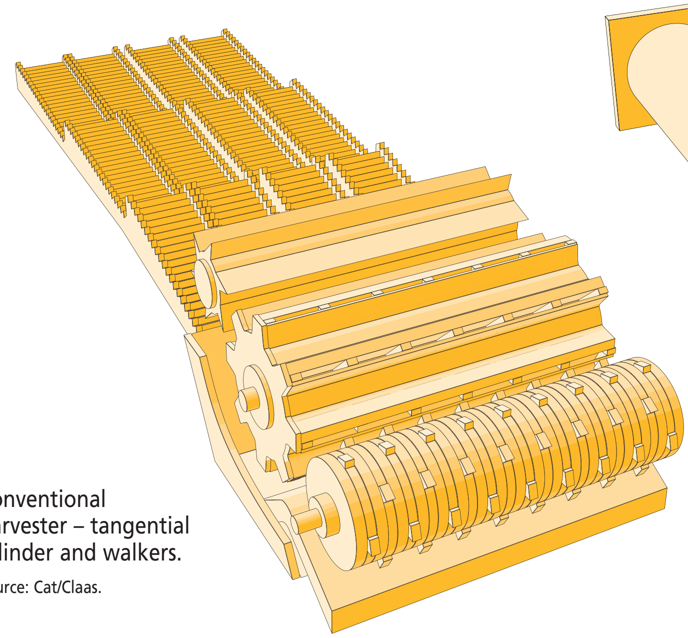
Rice plants are susceptible to lodging. Prior to the adoption of high-yielding varieties and laser-levelled rice fields, rice was traditionally a long-straw crop, bred to grow in standing water of variable depth and easily knocked down by storms.

But even modern varieties which mature faster with shorter straw lengths, still tend to be green at harvest time and patches or even whole fields of lodged crop are not uncommon. The machine needs to be designed to pick up and process this lodged material if excessive losses are to be avoided.

Categorising harvesters

Harvesters are categorised as either walker-type or rotary harvesters, according to the method of feeding the thresher (see Figures 1 and 2).

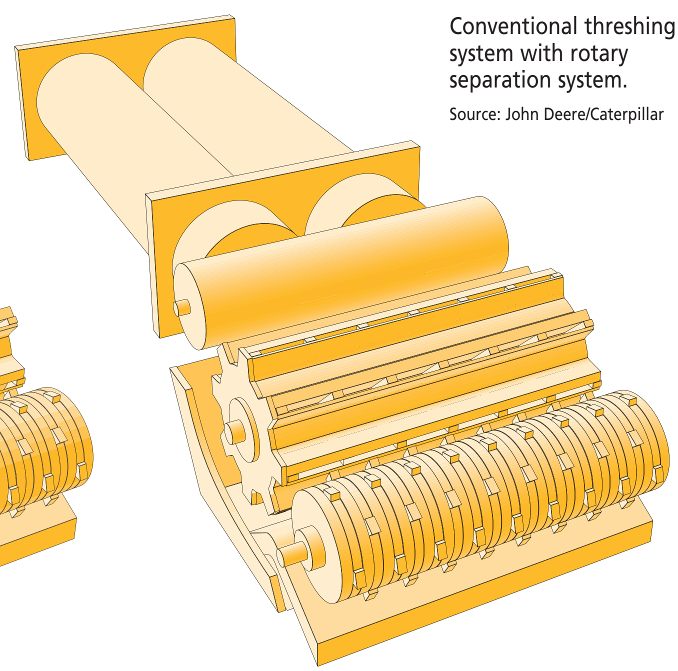
FIGURE 1 Walker-type harvester



Conventional harvester – tangential cylinder and walkers.

Source: Cat/Claas.

FIGURE 2 Rotary harvester



Conventional threshing system with rotary separation system.

Source: John Deere/Caterpillar

Harvester functions

A harvester is like a 'factory on wheels' (see Figure 4 on page 8). It performs the following basic functions in a rice field :

- Gathering.
- Threshing.
- Separating.
- Cleaning.
- Transport of materials.

Harvester performance

Understanding how a harvester works is essential if it is to be operated at its most efficient level. This is especially important when it is considered that some of the biggest machines cost up to $400 an hour to operate, that rotary-type separation is here to stay and stripper fronts are assuming an important role on rice fields — about 25% of the total rice crop was gathered with stripperfronts in 1998.

For top performance, each of the basic functional areas of a harvester needs to be coordinated with the other. Attention needs to be paid to what each function does and what adjustments need to be made to achieve best performance.

Harvest equipment must be maintained in good mechanical condition. No amount of adjustment can make up for defective or missing parts. Even rust and worn metalwork affect crop flow and machine performance.

Harvesting equipment must be operated correctly at the right speeds for the crop type and its condition at the time in the day or in the season.

Correct settings are a compromise between throughput and grain quality. This can be checked by measuring the levels of pearled or machine broken grain in the seconds elevator. Fan blast settings also need to be monitored to avoid putting a dirty sample in the bin.

Harvester adjustments

The first thing to remember is that an adjustment to a harvester in one area affects performance in another.

Any setting which increases the amount of straw or MOG taken in at the front, such as lowering the cutterbar to gather more of a lodged crop and get all the down grain, may overload the walkers or separation area of a rotary.

Driving the harvester too fast may overload the sieves. Overloading the engine causes the threshing system to slow or slug. Inadequate MOG intake under low moisture crop conditions can lead to uneven flow across the platform or grain damage from the threshing cylinder.

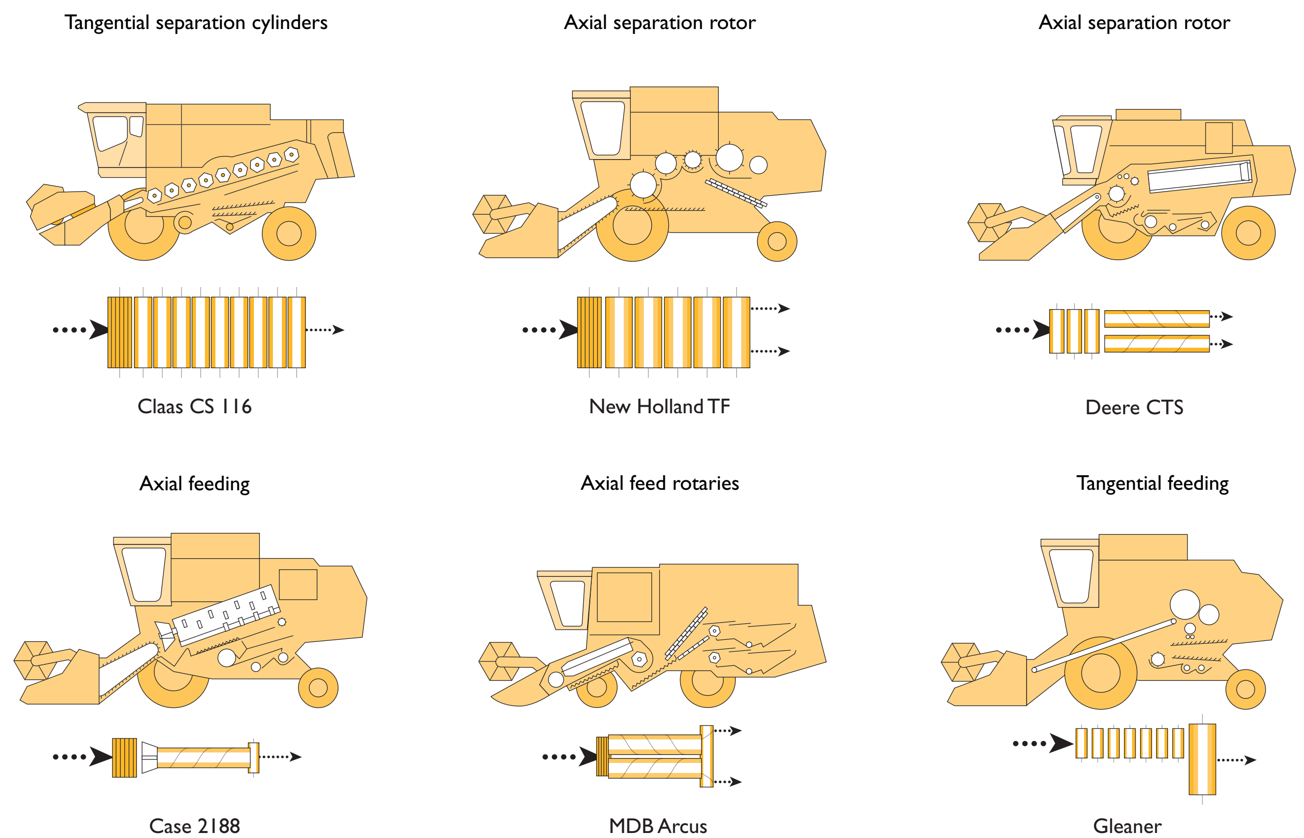
Some important points to remember are:

- Different varieties of rice and changing conditions may require a different series of adjustments.
- Adjustments should be thought through and made in sequence.
- Adjustments should be made one at a time.
- Performance must be checked under normal steady load, because any change in load can affect performance greatly.

Behind the front

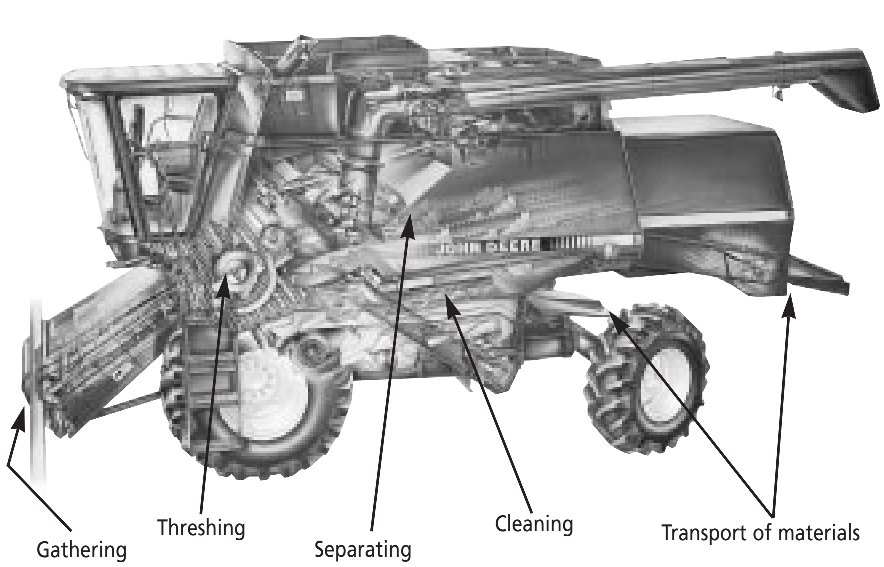
Feed elevator — Cut crop is conveyed up the feeder house to the threshing zone. The aim for top performance in a well-coordinated harvester is to have smooth crop flow, without unevenness, slugs or bunches of

FIGURE 3 Tangential feed and end feed



Sources : Manufacturer literature. Note: New Holland TF Series not available in Australia. The Claas CS 116 is no longer a current model.

FIGURE 4 Harvester functions



John Deere

material. Cylinder slugging impedes threshing, changes cylinder momentum, and increases losses.

A good operator will fine-tune threshing settings to the conditions at the time; sudden deviations in crop flow rate can upset settings and cause losses.

With the conventional tangential-flow thresher, both the cylinder and concave are usually fitted with spike teeth for rice. Raspbars used for cereals generally do not have enough 'traction' to cope smoothly with the volume of tough and moist rice straw, although they do a good job of dislodging the grain. A raspbar drum can be used with a stripper front installed. A spike tooth cylinder can be used for other small grains. On the other hand, the thresher should be set to leave the straw as near whole as possible in order to make it easier for the kernels to fall through the straw mat moving over the walkers — MOG will pack together less if it is not broken up.

Using less rows of teeth on the concave reduces the degree of straw breakage. Therefore only sufficient concave teeth should be installed as to retard the straw long enough on its passage through the threshing zone to allow all the grains to be loosened by the impact, combing and rubbing action of the thresher. Broken straw also overloads the cleaning system.

Threshing settings

Aim to have the cylinder-rotor and concave adjusted to detach practically all the grain from the panicles and separate as much grain from the MOG with minimal damage to the grain and as little straw breakup as possible.

Generally, a high cylinder speed and wide concave clearance will provide the greatest capacity and the least problems in separating and cleaning.

To arrive at the best setting:

- Adjust cylinder-rotor speed so that it operates as fast as practicable without causing serious grain damage and shelling or pearling. For rice, cylinder-rotor tip speed should usually be around 25–32 metres per second or 550rpm. The spike cylinder on Deere's CTS on the other hand is recommended at 14–19 m/s (400-550rpm), because the slower-moving cylinder on the CTS has twelve rows of teeth with three rows on the concave. A proportion of the threshing is meant to be done by counter-rotating separator rotors running at fixed 700rpm.
- Set cylinder-concave clearance by steps, starting with a wide setting and adjusting until it is close enough to just thresh out the grain without too much pearling. There should be no more than 5% pearled rice grains.

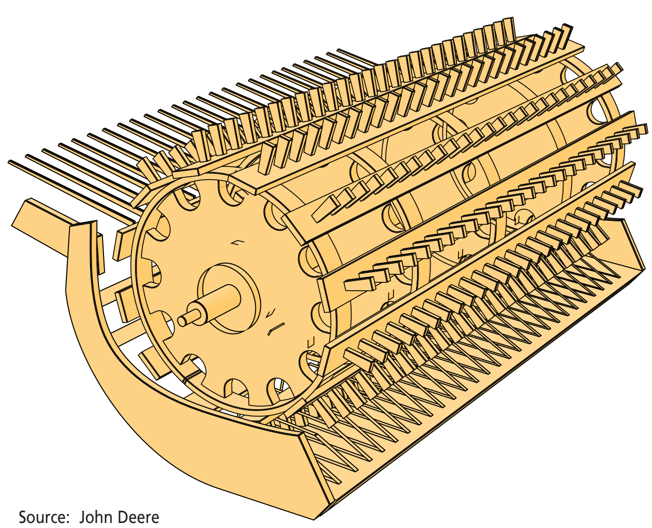
To return tailings:

- Unthreshed heads that make it past the thresher can be collected over the sieves and returned by the tailings return system to face the threshing action a second time.

Gauging the threshing action:

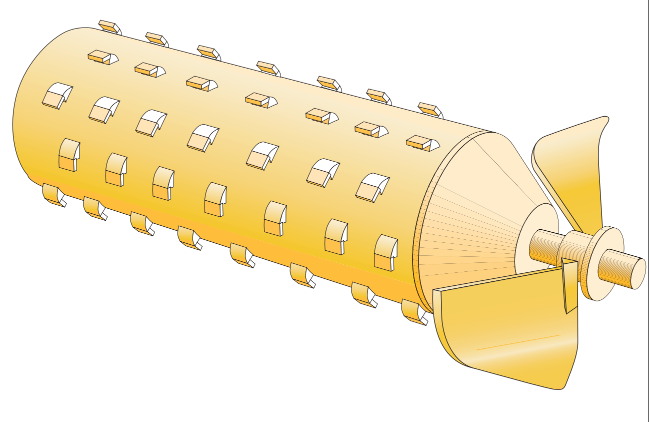
- Examine the grain in the tank. Visual inspection is the primary control measure.

FIGURE 5 Conventional spike tooth cylinder and concave



Source: John Deere

FIGURE 6 Case-IH Axial-flow specialty rotor



Source: Case

- Check the tailings return flow through the inspection port. Excessive tailings will lead to grain damage. Hidden damage is more difficult to detect since it shows only after milling. Some operators trade off between pearling and tails on grain. Watch for excessive pearling — high levels will cause a fall in grain millout. Monitor the sample regularly for pearling and to check trash levels.
- Examine the straw discharged out the rear of the harvester. It should contain only the occasional low-quality grain in the otherwise empty panicles or heads.
- Do a harvester 'quick kill', see section on page 9.

Walker-type and rotary machines

The traditional walker-type of separation system relies on gravity to sort the grain from the MOG.

Higher capacities overload a walker to the point where the grain cannot penetrate the straw in time and grains 'walk' out the rear of the harvester. Walker loss in rice has been known to be a problem for some models of walker-type harvesters. To combat the problem, machine designers have relied on increasing body width to thin out the straw mat to increase crop processing capacity while trying to stay below the 3% machine loss criterion accepted by the rice industry.

But there is a limit, set by body envelope and transport width. After that, a rotating agitator over the top of the walkers, such as that in the FNH TX66, or additional agitators have been built in to improve separation performance.

John Deere have developed the CTS (cylinder-tyne separation) model harvester, which has regular tangential-flow threshing (spike-tooth 12 row cylinder) then axially-aligned twin rotor separation. The CTS tangential cylinder runs slower and part of the threshing is performed by the separating rotors.

The 1996 Claas/Caterpillar Lexion harvester also has twin rotor separation, as does the TR series from New Holland.

In rotary thresher-separators the crop travels full circle around the rotor, relying on centrifugal force to drive the grain through the straw and out of the concaves-grates. The crop material might pass around the rotor from four to up to 12 times in the threshing-separating process. Case's Axial-Flow, New Holland's Twin Rotor AGCO Gleaner and Massey Ferguson's White use this rotary system.

Manufacturers of rotary separation machines claim a number of advantages over walker-type separators:

- Smaller machine envelope.
- Reduced number of moving components.
- Less drives and drive assemblies.
- Lower machine vibration levels.
- Less sensitivity to rotor speed and clearance.
- Higher rotor inertia.
- Lower grain damage.
- Lower harvester weight.

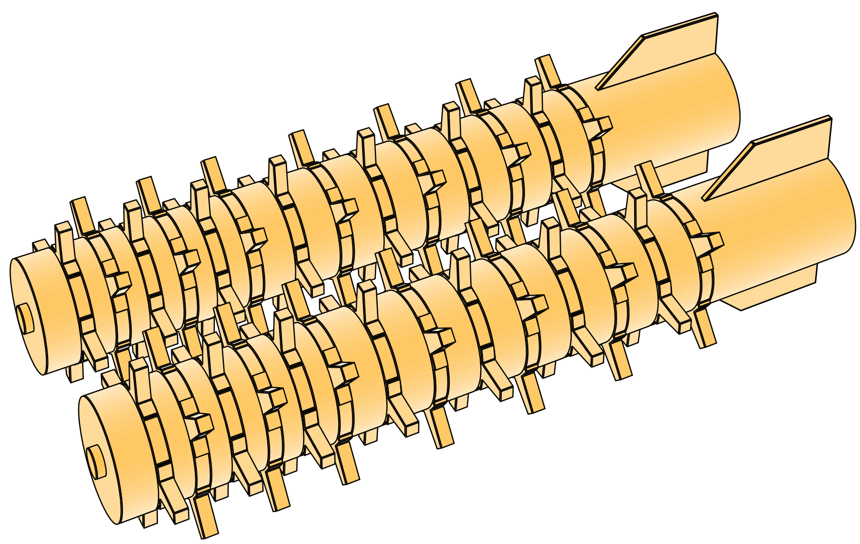
Manufacturers of walker-type separation machines claim a number of advantages over rotary separation machines.

- Lower engine power requirements.
- Reduced drop in capacity as moisture levels rise.
- Less difficulty in removing material plugs.
- Less changes from crop to crop except for peg drum.
- Less break up of straw.
- Less changes and cost when changing between standard and stripper fronts.

Irrespective of the system used, correct walker or rotor speed is critical to the separation process. Rotor speeds that are too high tend to bounce or propel grain over or out of the separator and slow speeds allow excessive straw and chaff to reach the cleaning area.

Generally, changing the speed of a walker from the factory setting is not recommended. Rotary harvesters are less sensitive to rotor speed and concave clearance changes are usually larger; for example 12 millimetres for the front of the cylinder versus 25mm for the Case rotor-concave clearance.

FIGURE 7 Separator rotors — John Deere CTS



In some rice field conditions, the separator rotors on the CTS can be slid out the back on rails for servicing or unplugging. The separators also carry out part of the threshing.

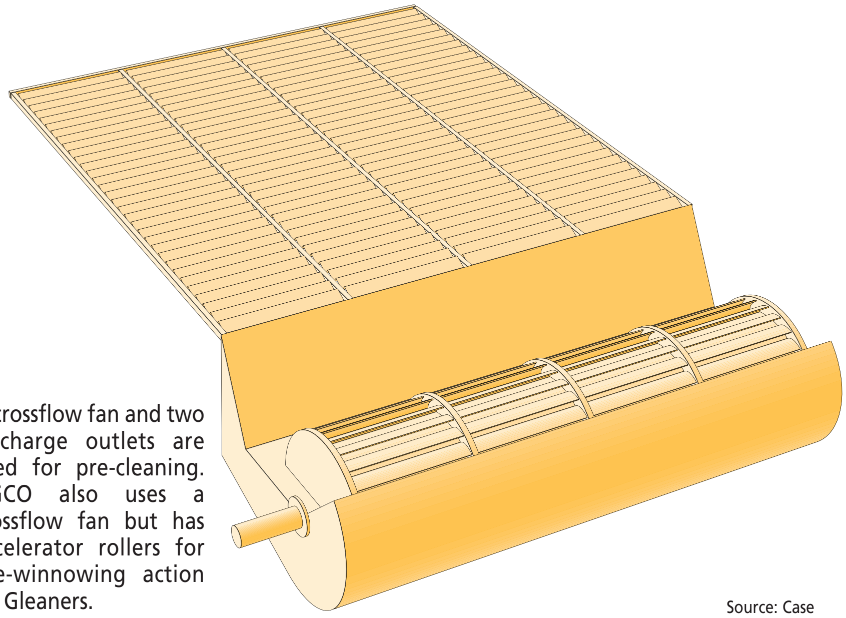
Source: John Deere

The cleaning system

The cleaning fan, adjustable chaffer and sieves remove the fine straw pieces, chaff and dust from the grain. As much wind should be used as possible. Many modern harvester models use twin discharge winnowing systems to pre-winnow the grain stream before it reaches the cleaning shoe area. Adjustable sieve openings are measured from the top of one vane to the tip of the next forward vane.

Cleaning system fan — Adjust wind to achieve maximum usable air volume without blowing grain into the tailings or out the rear of the harvester. With larger cropflows, for example with a

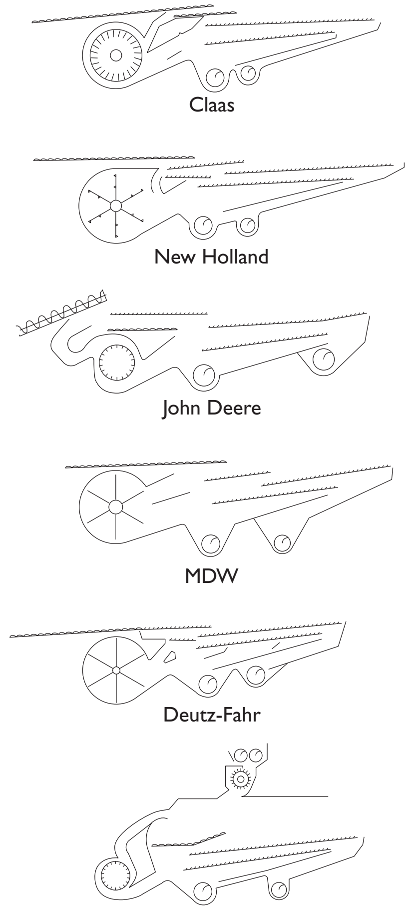
FIGURE 8 The cleaning system of the Case harvester



A crossflow fan and two discharge outlets are used for pre-cleaning. AGCO also uses a crossflow fan but has accelerator rollers for pre-winnowing action on Gleaners.

Source: Case

FIGURE 9 Cleaning system configurations



Source (Kutzbach et. al., CIGR A 069; 1996)

stripper attached or in very dense crop, direct more air to the front of the chaffer (three section upper sieve) with the windboard to compensate and improve cleaning. After setting the airflow, gradually close the chaffer sieve until any further closing would cause excessive tailings return. Then adjust the sieve in the same way.

Cleaning shoe-sieves — Most harvesters can be fitted with different types of sieves according to crop type. For rice and small grain cereals, the 28.5mm adjustable Closz slat-type chaffer sieve is suitable, initially set at a 9.5mm opening. The shoe sieve is set at 8mm initially.

The rear section of the chaffer sieve can be raised to retard material movement for better cleaning and less loss in light crop conditions.

Material transport

Harvesters are designed to carry rice and MOG through various processes.

- Conveying cleaned grain to the grain bin (clean grain conveyor).
- Returning tailings to the thresher (tailings elevator or conveyors).
- Discharging threshed material residues, usually by a beater onto straw and chaff spreaders, or straw chopper/spreader, where fitted.
- Grain unloading system.

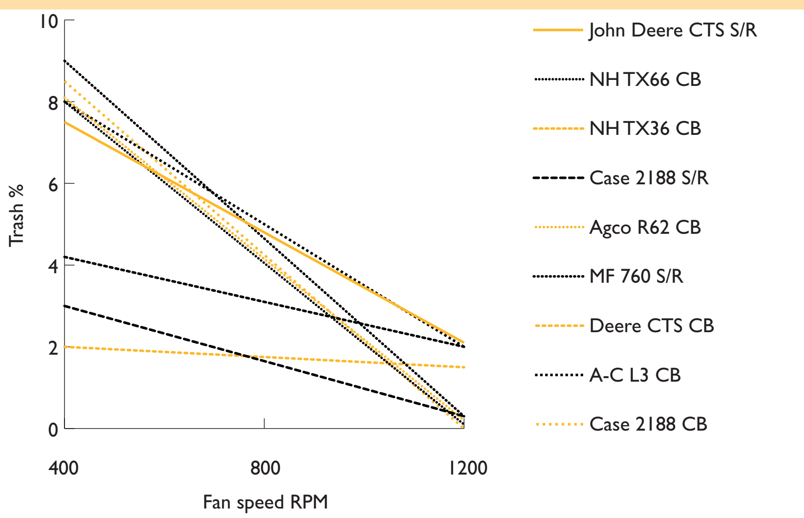
The returns and clean grain elevators are prone to high wear and should be fitted with special rice components, such as stainless steel sheet metal inserts and steel or wear-resistant plastic elevator flights.

Returns system — Most harvesters are equipped with a tailings return system, while some have a secondary thresher. The purpose of such a system is to segregate at the shoe any unthreshed heads and return them to be threshed a second time, either to the main thresher or to a secondary thresher on board.

Grain bulk transport — Gently convey clean paddy from the cleaning system (preferably not using an auger, to minimise paddy damage in the conveying system) to the grain bin.

Unloading from the harvester grain bin on the move saves precious field time, but the harvester must have the power to simultaneously harvest and unload; and an operator must be skilled enough to drive in the crop while managing the unloading operation at the same time. Grain is unloaded into a mother bin, into a truck driving alongside if field conditions are firm enough, or into a

FIGURE 10 Increase fan speed to lower trash



Research carried out during the 1997 harvest showed that increasing fan speed reduced trash levels.

John Deere

John Deere

Caterpillar

Three forms of ground drives for rice fields. High flotation tyres on front and rear -powered axle (left), half-track conversion (centre) and full-track as original equipment (right).

tractor-drawn or self-propelled chaser bin. Retract the unloader when not in use to avoid the risk of running the spout into obstacles. Be sure to watch out for trees or power lines with the unloader extended.

Spreading MOG — The body of the harvester concentrates crop material into a narrow swath or header trail by a factor of 3 to 5 if this is dumped back onto the field (ratio of header or front width to processing body width). Unless MOG is baled, the resulting header trails present problems in tillage and land preparation, as well as seeding a volunteer crop or providing a haven for pests and diseases.

For the increasing number of farmers practising some method of reduced tillage, a MOG distribution system or attachment is essential. A straw chopper, while power-demanding on the harvester, can save field operations by breaking up and shredding the crop residues for more even field distribution by the straw spreaders.

Tests have shown that spreading and incorporating straw increases the yield of subsequent crops, as well as providing a habitat for beneficial species. On Californian rice fields, which are on the flight path of migratory birds, straw management without burning is mandatory. Some growers elsewhere burn their header trails or windrows, but it is likely this practice will be forbidden in the future, due to public opposition.

Quick killing and unplugging

'Quick-killing' is a procedure using a stepwise sequence under the right conditions to deliberately stall the processing elements while the machine is fully loaded with crop. In all cases, consult the operator's manual. If the correct sequence is not used, turbo-charged engines may be damaged and there are other safety hazards if the procedure is not carried out correctly.

With the engine stopped and key removed, the processing areas can be studied when the covers are lifted to assess machine performance. For example, if there are loose grains in the agitated material inside the rotor near the rear of the grates in a rotary harvester, this may indicate excess rotor loss. Relatively few grains near the front of the grate area indicates a reserve of separating capacity.

This diagnosis can be used to check proper flow or evenness across the grain pan, chaffer sieve, grain front, feeder house and elevators.

If the rotor is choked on restarting, the appropriate unplugging procedure is needed to clear it.

Unplugging — If a heavy slug of crop cannot be cleared from the cylinder/rotor under normal operation, such as slowing forward motion, then a stepwise procedure is needed to unplug the processing elements. If the cylinder/rotor is plugged, first open the concave or lower the grates fully and run the separator to clear the cylinder/rotor.

If that does not work, raise the feeder, lower the safety stop, shut off the engine, remove the key and carry out the following steps:

1. Leaving the concave full open, remove all straw and other material from the front of the concave via the access opening.
2. Remove the cylinder/rotor drive cover shield.
3. Insert a breaker bar or rotor rocking wrench to move the cylinder/ rotor back and forth.
4. If this does not provide enough clearance, then in extreme cases, some of the concaves/grates may have to be taken out to remove the plugged material.
5. After clearing material, remove breaker bar and replace shields. Re-adjust concave to original position. Reset rotor gearbox and speed setting.

Trafficability

Rice field conditions often require a high flotation undercarriage on the harvester to prevent bogging or leaving deeply rutted tracks in the field.

Large flotation tyres, for example 35.5–32's on the drive axle of Class 7 harvesters, reduce ground pressure. Half-tracks are an option as an attachment for the wettest years since these can be fitted in place of the standard drive wheels. Full track conversions on the other hand require chassis and transmission modifications — unless they come as original equipment.

The small-area harvester harvesters made in Japan, Korea and Taiwan are usually full-track equipped, but those tracks are flexible and best suited to relatively firm or well-drained rice field conditions at harvest time.

Choosing rice harvester fronts

The capacity of the entire harvester is decided right at the front, and to maintain efficient harvester operation, crop needs to be kept flowing evenly into the machine.

Ground speed should be sufficient to maintain even flow across the platform. Forward speed is controlled not by throttle, but by the variable speed ground-drive control and gearbox. Engine speed must be maintained at a constant to keep the processor elements running steadily at their predetermined settings — essential for best performance.

Crop dividers can help lift and divide the crop ahead of the gathering head to improve the flow of gathered material and to guide the crop gently outside the cutting width to slide past the ends of the header with minimal grain loss.

Kondinin Group

Conventional grain head showing pickup reel, cutterbar and auger.

The purpose of the gathering head is to gather the grain bearing portion of the crop without gathering excess material, as this can affect the machines processing functions adversely. During the gathering process the machine must also provide enough material to the thresher for the crop to serve as a cushion and to minimise grain damage during threshing. Heads-first feeding is also desirable. There are four main types of rice gathering systems:

- Conventional grain head — cutterbar, reel and auger.
- Stripping type, or stripper head.
- Individual row pickup heads.
- Gathering attachments — vibramat, draper front, windrow pickup.

Conventional grain head

The reel — Reel performance is important in providing smooth crop flow into the header and the rest of the harvester, and there also are reel settings for minimum grain shatter. For rice, the pickup reel, when correctly adjusted, lifts and gingerly pushes the crop over the cutterbar. Bat reels are inappropriate. As the material is cut, the reel fingers sweep the cut material across the cutterbar and apron or platform into the path of the auger. The auger grabs the material and moves it towards the centre where the feeder fingers drive it under the front elevator or conveyor in the feeder house.

Reel height setting — In all conditions ensure that the reel tines clear the cutterbar by at least 25 millimetres. The reel bats should be just below the lowest heads; if the reel is too low, some heads will hang up on the bats and be carried around on the reel. If the reel is too high, the reel bars will shatter grain. In down crops, the reel should be low enough to lift the crop and sweep it through the cutterbar. Ensure the reel is the same height across the width of the header by means of the threaded adjusters.

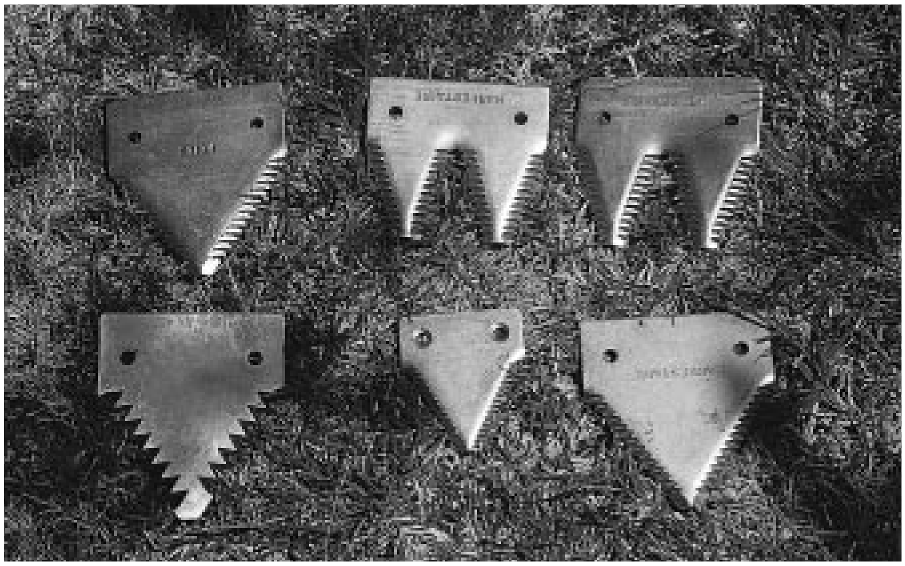
Reel speed — A normal setting is a reel index setting of 1.25. For a typical 1.1 metre diameter reel size this works out as a rule of thumb in reel rpm at six times the forward speed in kilometres per hour. If the reel diameter inceases, then the ratio should decrease by the same proportion. Reel index is the ratio of reel peripheral speed to forward speed, in the same units. Harvesters with automatic reel speed controllers have a typical range of 1.1 to 2.0 for reel index and, once a setting is chosen, reel speed is automatically taken care of when harvester forward speed varies. The auto reel controller needs to be calibrated for different tire sizes or header/reel types. In down and tangled crop, reduce reel index. *Reel tine pitch setting* — Careful adjustment of tine pitch is needed to ensure smooth crop flow into the cutterbar and auger. For average conditions, tine pitch is five degrees rearward. For down rice, adjust the tines to maximum pitch to lift the crop as much as possible without carrying material around the reel or dropping it on top of the auger. This will allow the cutterbar to be operated several inches clear of the ground, avoiding soil pickup and leaving any dead rotting straw behind.

Reel fore/aft position — In general, the reel is set more forward the faster the travel speed; but at all times ensure that the reel does not hit the cutterbar or auger in its lowest position. Also check that the reel is the same distance forward at each end. The exact positioning will depend on crop height and condition.

Cutterbars — There are some cutterbar variants available for rice other than the standard 76mm knife and guard combination. These include the 18mm Kwik-Cut (76mm stroke double cut); twin knife (Busatis balanced counter-cut) and the 3*2 combination (Herschel's Rice Bar with 76mm sections moving overstroke across 50mm super 7 fixed 50mm sections). There are also 76mm knife sections available for rice with a slotted profile for trash or green material clearance and special metal-plating treatments on knife sections to extend life. In every case, serrated sections are essential for rice.

Cutterbar cutting height — The cutterbar is normally set just low enough to gather the majority of the heads without gathering excess MOG. In weedy conditions the cutterbar can be set higher to reduce the amount of green material entering the processor which improves separating and cleaning functions — a loss of some grain may be better than overloading the processor with excessive green material, which may lead to time lost unplugging the harvester.

Cutterbar register — Checking cutterbar register is critical in rice, which is a tough-strawed crop to cut. Knife sections must centre exactly under the guards at end of stroke position. For an over-stroking knife, such as a 89mm stroke in 76mm guards; Herschel's 76mm knife over 50mm guards, or 76mm stroke in Kwik-cut 18mm knife, each of the knife sections must move an exactly equal distance each side of the guards or counter-edges. Failure to check register results in poor



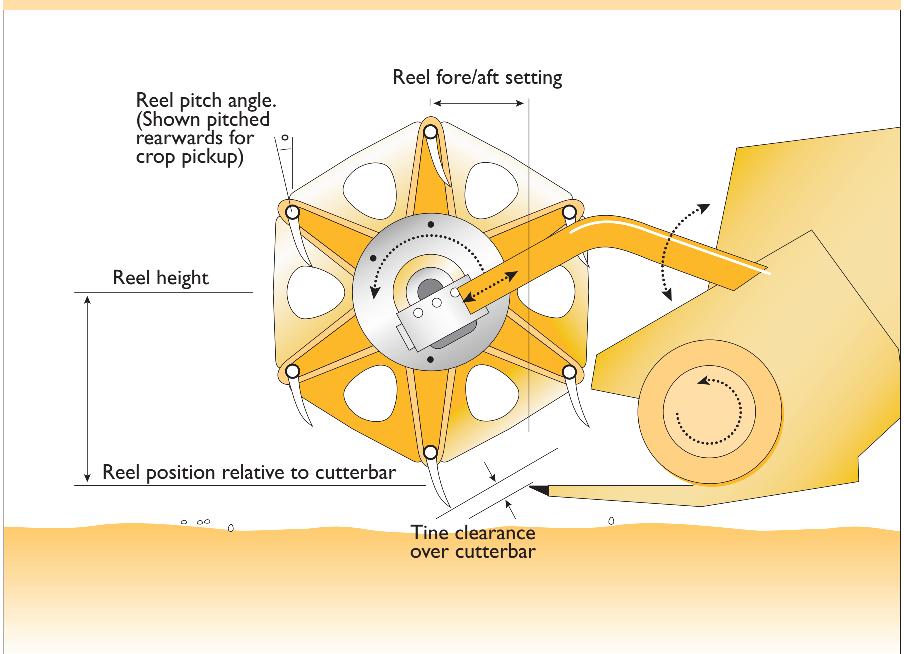
A range of cutterbar knives including double cut (top right) and more aggressive teethed standard sized knives. The smaller knife (middle bottom) is from a Massey Ferguson closed front.

cutting, material clogging the knife, uneven feeding over the platform, or in the extreme heavy driving and even premature knife drive or knifeback failure.

Cutterbar speed — Some conditions make it desirable to change cutterbar speed away from the manufacturer's set drive speed by means of a pulley change. Use a higher cutterbar speed for fast forward speeds, or in tough wet-cutting paddyfield conditions if these conditions are likely to be sustained for much of the season.

Platform auger adjustment — Position the auger as high as possible but so that it is able to move the crop uniformly without slugging, bunching or delaying crop movement. The auger flights should just clear the stripper bar so the crop is not carried over and around the auger. A normal clearance (factory setting) would be 3mm between stripper and auger flights. Normally, auger clearance above the header bottom should be 12.7mm or less. For heavy crop conditions, raise the clearance to 25.4mm for greater header capacity and less carryover by the auger. For tough green straw the auger may need to be adjusted closer to the header bottom, but the auger must not scrape or else there will be excessive wear to components.

FIGURE 1 The four main pickup reel adjustments and their effects



Shows reel settings, feathering-type pickup reel. Bat reels are unsuitable for rice harvesting.

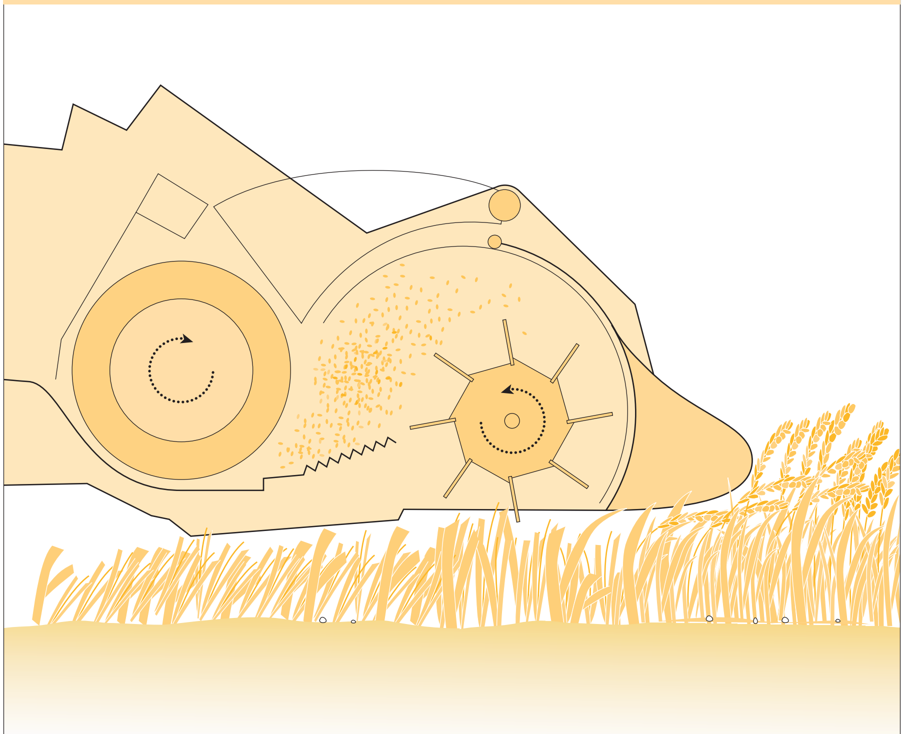
Auger retractable finger pitch — Factory setting has the auger retractable fingers in the raised or 'early extended' position to cope with the heaviest crop. In a short crop the adjuster may be used to extend the fingers and pitch them towards the feeder to facilitate crop feeding.

Auger speed — In heavy crop conditions, increasing auger speed will increase header capacity and improve crop flow. In light conditions, slowing the auger may be desirable to reduce grain shatter at the auger and lower platform grain losses.

Stripper fronts

The British-designed keyhole slotted rotor-type of stripper has been rapidly taken up on rice fields in the United States, Australia and South America since it was first tested in rice in 1989

FIGURE 2 The Shelbourne Reynolds stripper front, from Stanton England.



This stripper gathering front on latest models has a shaker conveyor between stripping rotor and platform auger for rice, but not for wheat. Cost is around $50,000 (depending on width). Shelbourne Reynolds employ eight rows of stripper teeth and a centre bearing on the bigger fronts which are available in widths of up to 8.4m. The slotted rotor principle was initiated by engineer Wilf Klinner at the Silsoe Research Institute, UK.

here in Australia. The stripper can increase grain throughput primarily by permitting higher forward speeds, reducing material other than grain intake by a factor of three or more and, as a consequence, improving grain separation efficiency and harvester performance in other ways.

The stripper works by using rows of flexible teeth on the rotor to pass upward through the crop, removing grain and a proportion of the MOG, see Figures 2 and 3.

Depending on crop conditions, MOG intake is reduced and the rotor threshes 50–95% of the grain. This capability means that forward speed and grain throughput can even be doubled compared with a cutterbar head in good paddyfield conditions. Trash levels need to be monitored.

High speed for low loss

The stripper rotor has an unusual characteristic: its gathering efficiency improves with forward speed. Losses are higher at very low speed and the amount of straw taken in at low speed is much higher as well. The stripper rotor performs best with a crop curtain or wall to prevent grain flying out the front or sides. For this and other reasons a stripper front should be slightly narrower (say 90%) than a conventional grainhead, for example, a 5.5m stripper compared with a 6.1m cutterbar on a 135kw Class 5 harvester, or 6.9m stripper opposed to a 7.6m cutterbar on a 195kw Class 7 harvester.

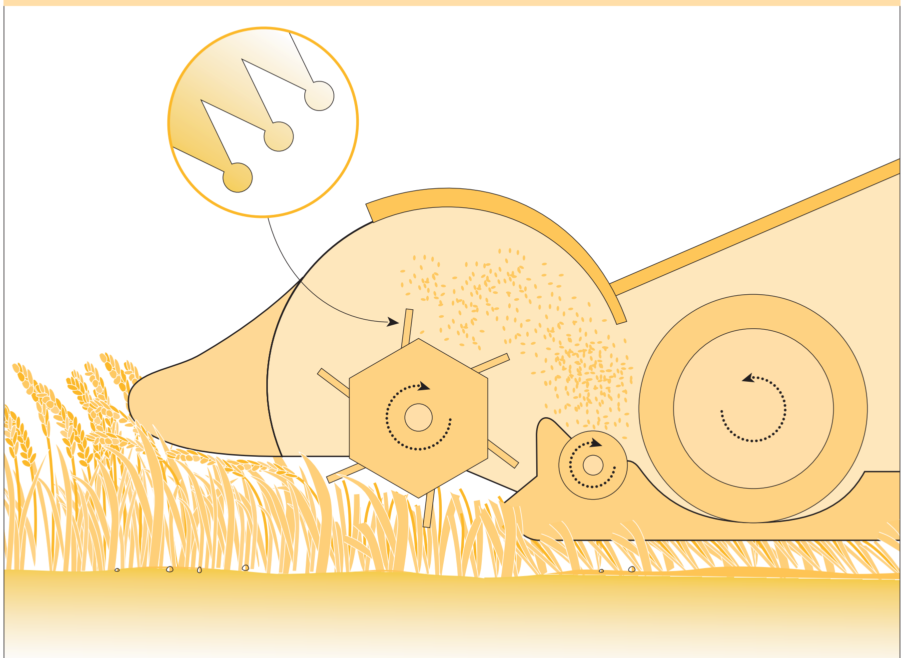
Stripper power and fuel

The stripper rotor itself has a higher power demand than a cutterbar, for example 12kw/m and so the harvester must have the shaft drive power take-off to the front to cope with the power requirement. One compensation is that the rest of the harvester is less loaded and in equal conditions. Some operators have recorded reduced fuel consumption by more than 15–25% with a stripper front fitted in rice, compared with the same machine fitted with a conventional cutterbar head. Older harvesters may need extensive modification to be able to drive and carry a stripper front.

Stripper front weight

The stripping header is more than 30% heavier than conventional cutterbar heads and this requires adjustment to the harvester gathering head hydraulic settings to reduce drop rate. Damage can result if the head lowers too fast. Greater care also must be exercised when driving to avoid nosing over — if the rear wheels of a harvester lift, steering control is lost.

FIGURE 3 The Western Harvest Hustler stripper front



The Western Harvest Hustler stripper front recently has been taken on by Agco. The design has six rows of the BTG-licensed stripping teeth on the stripper rotor and a roller transfer device to the floating platform auger for rice. There is no centre bearing. The machine features an external gear change lever. The gathering system on the harvester has to be shaft-driven to accommodate a stripper head gearbox.

More dust — The nature of the stripping process means that there is more dust at the front. Also the airflow entrained by the rotor has to be allowed to escape before the feeder, and trash can be higher.

Harvester modifications with a stripper front fitted — Modify position of front roller of the feed elevator per stripper manual instructions to enable even feed. Remove the dust cover plate on the feeder house, close concave clearance down, and follow any other instructions specific to the stripper and harvester combination to account for the reduced MOG input to the processing elements. Concave blanking plates or, in the case of rotary harvesters, a number of rotor/concave modifications are desirable with a stripper front fitted and these are specific to each harvester model.

Tests on strippers

One study in Australia showed that stripper fronts consistently increased capacity on suitably-adapted harvesters. Strippers also had higher gathering losses than a cutterbar, but the losses were within acceptable limits in rice in good conditions. There was no significant difference in grain quality between strippers and cutterbar fronts in Australian tests or between rotaries and walker-type harvesters. Lodged crop changes gathering performance greatly and increases stripper tooth wear.

Operational adjustments

The main settings for the stripper front are rotor speed, rotor hood position and rotor height.

When harvesting rice in good conditions, stripper rotor speed is best set at 400–500rpm, depending on crop moisture. Excessive rotor speed helps gathering but increases straw intake and wears out the stripper teeth faster. As initial settings, set the hood or cowl at mid position, rotor below the lowest heads and the tip of nose 100mm below average head height.

The aim is to position the rotor and stripper front as high as possible to keep straw intake down but low enough to lift and remove panicles, including those that are bent over. The harvester grain loss monitor can be used as a guide to gauge the best forward speed.

In laid crop the rotor must be lower and forward speed reduced. Rotor power increases markedly in lodged conditions because straw intake is higher; the rotor rpm will tend to fall and slip clutch may be engaged — on the Shelbourne Reynolds stripper front, a rotor speed monitor provides a warning of imminent overload.

Crop is gathered better when the harvester can be driven into the direction of lay and pick up the rice like a carpet rather than running down or across the laid crop.

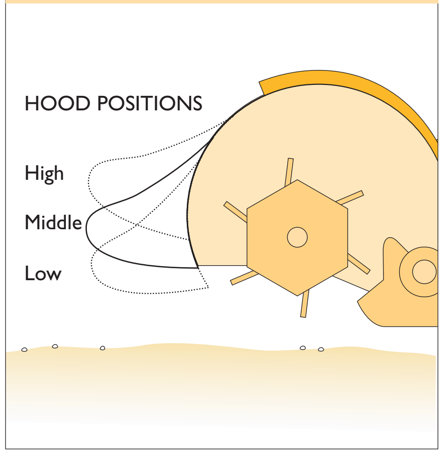
Stripper front adjustments

Concave clearances need to be closer with a stripper fitted to account for the much smaller MOG throughput (unless the crop is lodged).

In some harvesters, for example the Case axial flow, different concave grates are needed. Also on the Case 1688 and 2188 models, extra 'elephant ears' (four instead of two) should be fitted on the specialty rice rotor cone.

Fan speed needs to be faster and the sieves opened to cope with the extra grain throughput.

FIGURE 4 Stripper head field settings



The straw left standing behind a stripper poses fresh challenges in field management. A cutterbar attachment behind the stripper front might be a desirable option for stubble retention farming. In wheat stripper fronts are not considered economically viable at any speed in low moisture conditions.

Gathering attachments

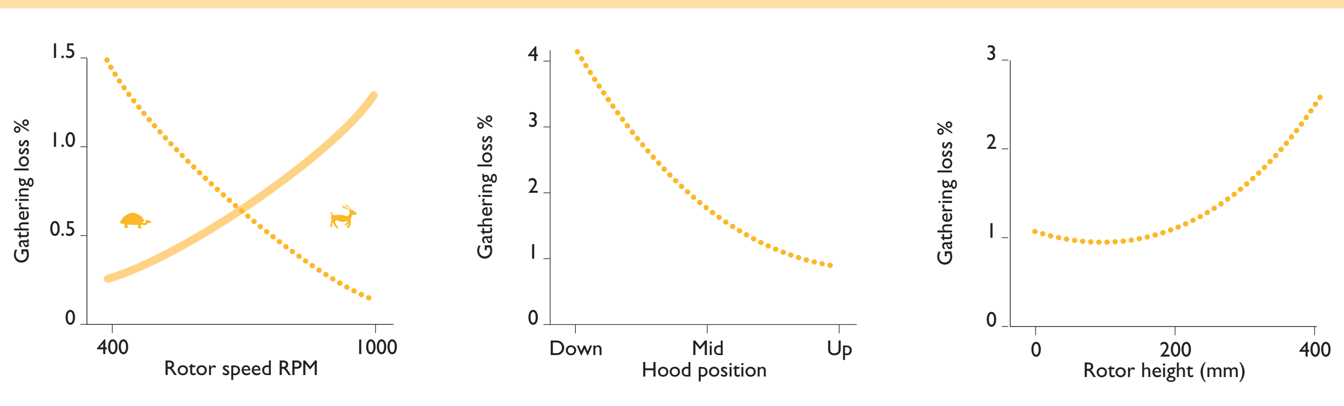
Vibramat, draper front, windrow pickup and lifters are all gathering attachments able to improve harvester performance.

If a cutterbar is used a Vibramat is a highly cost-effective attachment that will reduce gathering loss still further and improve crop flow.

The draper front is an expensive option that really stands out in lodged conditions. Advantages are smoother flow into the feed elevator and higher level of heads-first feeding which improves overall performance of the processor.

Lifters are specifically designed to raise lodged crop without the need to operate the cutterbar and platform at ground level.

FIGURE 5 Effects of stripper front field settings on gathering losses



Rice harvesters — current specifications

TABLE 1 Current rice harvester specifications

Model	Harvester Type	Front width (m)	Thresher diameter (mm)	Thresher width (mm)	Separation area (m^2)	Sieve area (m^2)	Grain tank (m^3)	Engine power (kW)SAE	Fuel capacity (litres)	Front tyre
CASE										
2388	Rotary	6.10	762	2790	1.70	5.13	7.40	194	466	35.5x32
2366	Rotary	5.30	610	2790	1.22	3.82	6.30	160	350	30.5x32
CATERPILLAR										
LEXION 460	Conventional	7.60	600	1700	9.85	5.82	10.50	216	650	N/A
LEXION 480	Drum/Rotor	7.60	600	1700	8.20	5.82	10.50	272	650	N/A
GLEANER (AGCO)										
R62	Rotary	6.10	635	2286	3.32	4.92	10.60	170	568	30.5x32
JOHN DEERE										
9610	Conventional	6.70	660	1638	7.50	4.98	8.50	201	530	35.5x32
9510	Conventional	6.10	660	1362	6.25	4.11	7.20	175	530	30.5x32
CTS II	Drum/Rotor	6.70	660	1362	N/A	4.11	7.20	201	530	30.5x32
MASSEY FERGUSON										
8680	Conventional	6.10	635	1580	8.62	4.92	10.57	195	568	N/A
8780	Rotary	6.10	700	3560	2.87	4.40	8.10	195	510	N/A
NEW HOLLAND										
TX66	Conventional	7.50	610	1580	6.62	6.52	8.00	201	600	35.5x32
TX64	Conventional	6.10	610	1300	5.52	5.41	7.20	160	450	30.5x32
Older models suited to rice harvesting										
ARBOS										
1000	Conventional	4.20	600	1560	7.20	NA	6.80	165	280	23.1x26
125	Conventional	3.20	600	1150	4.91	2.39	3.00	89	220	23.1x26
CASE/INTERNATIONAL										
2188	Rotary	6.10	762	2790	1.70	5.13	7.40	194	466	35.5x32
2166	Rotary	5.30	610	2790	1.22	3.82	6.30	160	350	30.5x32
1688	Rotary	6.10	760	2770	1.70	5.13	7.40	194	467	30.5x32
1666	Rotary	5.30	610	2770	1.20	3.86	6.30	160	348	30.5x32
1680	Rotary	6.10	760	2770	1.70	5.13	7.40	175	470	30.5x32
1660	Rotary	5.30	610	2770	1.20	3.06	6.34	142	350	30.5x32
1480	Rotary	6.10	914	1560	1.70	4.03	7.28	143	473	30.5x32
1460	Rotary	5.30	610	1184	1.20	2.98	6.30	127	350	24.5x32
CLASS										
MEGA208	Conventional	6.10	450	1580	8.67	5.65	7.50	DIN 176	500	30.5x32
MEGA204	Conventional	6.10	450	1320	7.22	4.70	6.20	DIN 147	400	30.5x32
116	Multi-rotor	6.10	450	1580	6.35	5.65	8.00	203	500	24.0x32
114	Conventional	6.10	450	1320	5.50	4.25	N/A	163	NA	N/A
108SI	Conventional	6.10	450	1580	7.95	5.10	7.50	163	400	30.5x32
98SL	Conventional	6.10	450	1320	6.60	4.25	6.20	147	400	30.5x32
88S	Conventional	5.30	450	1320	5.95	4.25	5.20	118	300	24.5x32
68	Conventional	5.30	450	1160	4.86	N/A	3.20	77	200	23.1x26

TABLE 1 Current rice harvester specifications (cont.)

Model	Harvester type	Front width (m)	Thresher diameter (mm)	Thresher width (mm)	Separation area (m^2)	Sieve area (m^2)	Grain tank (m^3)	Engine power (kW)SAE	Fuel capacity (litres)	Front tyre
DEUTZ										
3610	Conventional	6.10	600	1521	8.05	4.64	6.30	144	345	30.5x32
1322	Conventional	6.10	600	1270	6.15	3.84	4.60	118	300	18.5x30
1202	Conventional	5.60	565	1160	4.86	3.52	3.00	81	260	23.1x26
GLEANER										
L series	Conventional	5.30	490	1220	7.60	4.00	7.05	108	333	23.4x34
R50 (P6 thresher)	Rotary	5.30	635	1724	N/A	3.97	7.05	141	379	24.5x32
JOHN DEERE										
9600	Conventional	6.70	660	1638	7.50	4.98	8.50	201	530	35.5x32
9500	Conventional	6.10	660	1362	6.25	4.11	7.20	175	530	30.5x32
CTS	Drum/Rotor	6.70	660	1362	N/A	4.11	7.20	201	530	30.5x32
8820	Conventional	6.70	560	1664	6.35	4.38	7.82	168	379	24.5x32
7720	Conventional	6.10	560	1397	5.30	3.63	6.70	123	379	24.5x32
1075	Conventional	6.10	610	1300	4.75	4.30	6.00	110	300	23.1x26
1065	Conventional	5.30	610	1040	3.80	3.63	4.40	92	300	23.1x26
975	Conventional	6.10	610	1300	4.72	4.60	4.20	110	300	23.1x26
955	Conventional	5.50	610	1040	3.80	3.06	3.52	77	175	23.1x26
LAVERDA										
3900	Conventional	6.10	600	1600	7.94	5.51	7.00	165	380	28.0x26
3800'S	Conventional	6.10	600	1600	7.94	5.51	6.58	147	320	23.1x30
3700'S	Conventional	5.30	600	1350	N/A	4.56	6.00	114	320	23.1x26
MASSEY FERGUSON										
860	Conventional	6.10	560	1520	6.52	3.90	6.35	182	340	24.5x32
850	Conventional	6.10	560	1270	5.60	3.30	4.95	149	340	23.1x24
760	Conventional	6.10	560	1520	5.47	N/A	6.34	112	242	24.5x32
750	Conventional	6.10	560	1270	4.69	N/A	4.93	97	N/A	23.1x30
NEW HOLLAND										
TX34	Conventional	6.70	600	1300	4.36	4.40	6.00	135	350	N/A
8080	Conventional	6.70	600	1560	7.35	4.97	6.34	153	350	16.0x20
8070	Conventional	6.70	600	1300	6.14	4.13	4.57	85	300	12.0x18
8060	Conventional	6.70	600	1300	6.14	4.13	4.57	85	300	12.0x18
8040	Conventional	6.70	600	1040	3.79	2.80	3.17	77	250	13.0x18
1550	Conventional	6.70	600	1250	4.88	3.87	3.50	101	250	10.5x18
1545	Conventional	5.80	600	1250	4.57	3.33	2.61	82	160	10.5x18
1540	Conventional	5.80	600	1000	4.00	3.08	3.20	82	250	10.5x18
1530	Conventional	5.20	600	1000	3.71	2.65	2.37	76	160	10.5x18
WHITE										
9720/9700	Rotary	6.70	800	4.27	N/A	N/A	9.33	184	378	30.5x32
8900	Rotary	6.70	600	1270	6.00	4.00	4.50	100	300	N/A
8920	Rotary	6.70	600	1270	6.00	4.00	4.50	100	300	N/A

Note:

Rice specifications of harvesters vary greatly on older machines and often do not include rear-assist drive wheels.

Stainless steel panelling in high-wear areas such as front floors, grain elevators and auger flighting has become standard in the last seven years.

Four-wheel drive kits have also recently become standard.

Measuring and reducing harvest losses

Reducing harvest losses can be worth an extra $50 per hectare or more in the ricegrower's pocket. Modern harvesters are equipped with loss monitors, but even the most sophisticated of electronic loss monitors has to be calibrated periodically. To do this requires getting out and physically counting grains on the ground.

Kondinin Group

The rice plant. Crop losses intensify when the plant lodges (lays down, flattens due to weak stems or being pressed down by external forces), or the grain shatters or sheds from the ear before harvest, or weather adversely affects the grain or delays the harvest.

Economic impact of losses

The operator has to decide what loss level to accept under given field conditions and the time available for harvest. The harvester settings and travel speed are then adjusted accordingly. Losses can occur during pre-harvest, harvest or post-harvest. Post-harvest losses are covered in the next chapter.

Total field loss	=	Pre-harvest loss + Machine loss

Pre-harvest, or crop loss takes place before the crop is harvested and occurs due to normal maturation processes, or weather, disease and pest attacks. This loss cannot be recovered during the harvesting process.

Spot-checking and sampling

Crop loss can be assessed in a typical unharvested area using a loss-measuring frame.

For sampling, a frame of dimensions 316 millimetres square or 357mm inside diameter (both equal 1/10 square metre) is placed randomly on the ground within the crop. Seventeen to 24 rice grains on the ground in the frame size is equal to a 50 kilograms per hectare loss (or one bushel per acre within a one square foot frame).

The precise figure for the number of grains depends upon seed weight — a notional example would be 24 grams per thousand grains of paddy. At least five and preferably ten samples should be taken to average out field and other variability with this frame size.

To measure machine loss of a self-propelling harvester, it is important to locate exact loss causes before any adjustments are made to the machine. Machine losses are made up of the sum of gathering or header front loss and body or processing separator loss.

Measuring harvester losses

The harvester should be driven at regular speed without using the straw or chaff spreaders, then stopped in an area of the field that represents average field conditions. This excludes the edges of the field or the end of a run.

When the harvester has cleared after stopping, it should be backed up a distance equal to one harvester length. All losses can be checked there without starting and stopping again in that area, as shown in Figure 1. For safety, the machine must be shut down completely before starting loss evaluations.

Pre-harvest loss is counted in frames dropped in area 1, gathering loss in area 2, (calculated by subtraction), and processing loss in area 3.

Processing loss, measured in area 3, that is under the swath directly behind the separator, consists of threshing plus separator plus cleaning shoe plus body leakage loss.

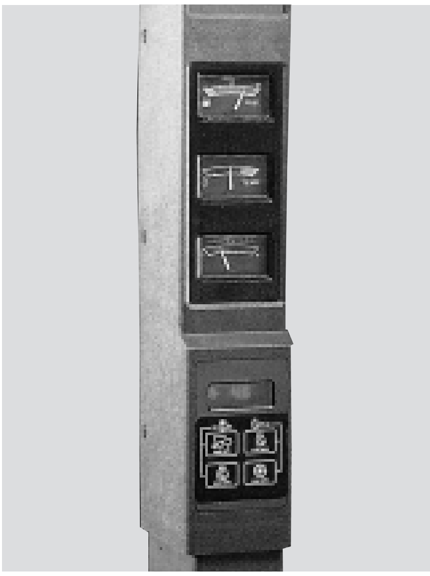
Gathering loss is caused by cutting too high or reel shatter. To calculate gathering loss, subtract loss in area 1 (pre-harvest) from loss measured in area 2 .

Processing loss is made up of threshing plus separator plus cleaning shoe plus body leakage loss, and is measured in area 3, in and under the swath directly behind the separator. Note that grains are concentrated in this area by the harvester and a multiplier must be applied to these figures to account for the concentration of the crop being brought in from the full gathering width to body width.

Pre-harvest loss (area 1) and gathering losses (area 2) must be subtracted from loss in area 3 to calculate separating loss. Alternatively,

TABLE 1 Grain weight and seeds in a loss-measuring frame — rough rice

GRAIN TYPE	Thousand grain weight, g.	Grains per kg. (median)	lbs. per US Bushel	Kg. per cubic metre	Seeds in one measuring frame (1/10 m2) = 50 kg/ha.
LONG GRAIN	21–24	44,643	42–45	540–580	21–24
MEDIUM GRAIN	23–25(27)	41,740	44–47	570–600	20–22
SHORT GRAIN	26–30	35,898	45–48	580–620	17–19



John Deere

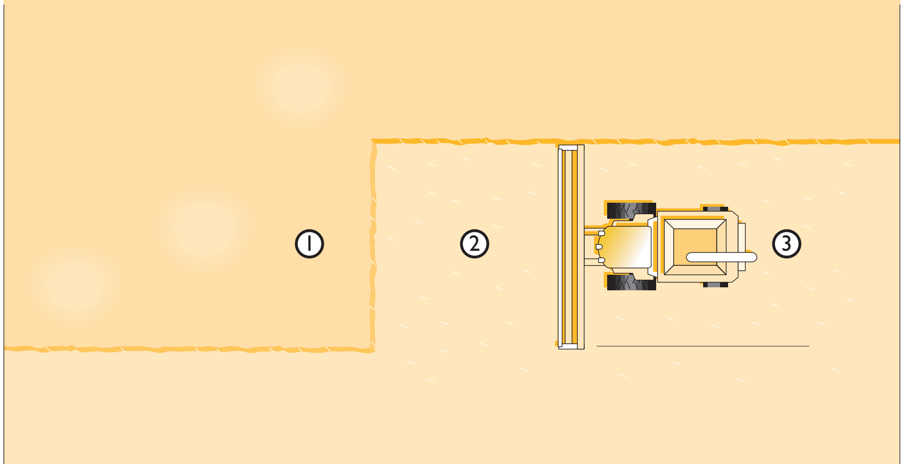
John Deere's Harvestrak harvester monitor checks grain loss by measuring a representative sample of losses over the walkers and shoe — a change in loss rate is indicated by the panel meter. The monitor also indicates an overload and slow down in a processing component when the needle swings suddenly to the + side of the panel meter.

a suitably-made half-width gathering loss frame may be used in area 3. Take this concentration into account.

Optimum harvester operation is a compromise between forward speed, gathering height and threshing settings under the prevailing conditions to get the crop in with a minimum of delay, yet with an acceptable level of losses: it is a balance between processing losses and delay losses.

Any statement about harvester grain throughput needs to be accompanied by the relevant loss level to be meaningful.

FIGURE 1 Measuring harvester losses



In a uniform area of crop, back the machine by one length to measure losses.

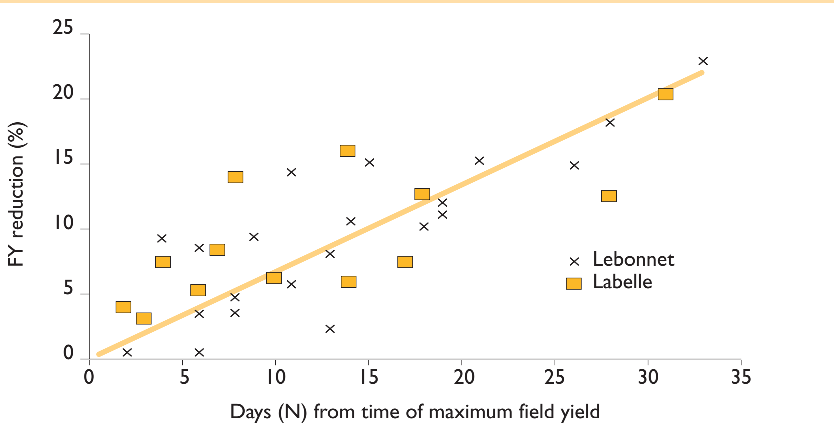
International standards (ANSI/ASAE S343.3) state that a machine loss level of 3% is acceptable under good crop and machine conditions at the maximum sustained feed rate for harvesters in rice (ASAE Standards, 1995).

Harvester loss monitors

Loss monitors generally do not measure actual loss quantitatively, but provide a guideline or indicator to the driver based on measured electronic signals from devices in the body that provide a relative number (such as number of seeds impacting against sounding boards in a given time) or an analog needle position.

Periodic field checks are necessary for the read-outs to have any bearing on machine performance under the given conditions. Field checks are a form of calibration to ensure that losses are roughly proportional to the signal on the read-out in the cab.

FIGURE 2 Timeliness effects in Arkansas rice



Field yield reduction for the varieties Lebonnet and Labelle.

Source: Lu, Siebenmorgan, Dilday and Costello, 1992.

Forward speed and thresher settings can be fine-tuned to local conditions using the monitor to avoid excessive losses. When the operator has adjusted his harvester and header to an acceptable loss level, the monitor can be set to this level, thereafter indicating whether to increase or decrease ground speed. Another important use for grain loss monitors is to indicate if some processing component has stalled, such as a thrown drive belt or the machine is slowing or is becoming plugged, as for overloaded straw walkers, sieves or return elevator.

Loss monitors perform best in uniform conditions and when the harvester is being operated near its maximum throughput. In damp, difficult or changeable conditions the readings can be erratic and misleading; under those circumstances it is best to switch off the monitor. The cost of losses can be calculated from the estimated average loss (kg/ha) multiplied by area harvested (ha) times the crop value ($/kg farmgate price). A good manager would balance economic losses incurred by pushing the machine harder against productivity gains from getting the job done faster or before inclement weather reduces crop returns.

Time harvest to minimise losses caused by:

- Reduced grain yield
- Lower grain weight
- Higher trash levels
- Reduced whole grain
- Lowered premium — quality effects
- Shedding and lodging.

The rice harvest and grain quality

TABLE 1 Paddy characterisation by grain shape

Grain type	Ratio of L/W	Grain length (mm)	Paddy grains/kg
Short	1.5 to 2.5:1	7.4–7.5	35.898
Medium	2 to 3.1	7.9–8.2	41.740
Long	> 4.1	7.9–9.6	44.643

Most paddy must be dried, it cannot be left long in the field and it cannot be kept wet.

Holding a large quantity of freshly-harvested paddy for more than a day in high humidity conditions can reduce its value greatly. This is a crop that is mature at a high moisture level (20–27 per cent). It will dry down if left standing, but then head shatter, pests and weathering take their toll. High moisture paddy is vulnerable to rapid deterioration and needs immediate action to control grain moisture and temperature if quality is to be maintained. The safe moisture level for storage depends on grain condition and variety, the storage environment, and climate. Paddy can be safely stored up to 2 or 3 months at 12–13% moisture content wet basis. For long-term storage, dry the grain below 12.5%.

Paddy hygroscopy

Rice grains are hygroscopic and will gain or lose moisture to equilibrate with ambient air.

Atmospheric humidity and temperature govern the equilibrium moisture level of paddy. Under the conditions found in the humid tropics; for example at 85% relative humidity (RH) and 30 degrees Celsius the equilibrium moisture content of paddy is around 16%.

Standards for rice quality

The impact of harvest on post-harvest processes needs to be examined because rice is required as whole grain (unlike other cereals), and the harvest has a major effect on whole grain quality, which shows up when rice is dried and milled.

Underlining this is the need for quantifiable methods of measuring rice quality. Quality criteria for price and market quality of milled rice are not related to criteria for cooking and eating quality or for nutritional quality of the cooked rice. The issue is complicated by the fact that freshly-harvested rice undergoes textural changes during the first three months of harvest, so milling tests and tests for cooked rice are preferably done on aged rice. Rice is in the first place categorised and marketed according to grain size and shape that is long, medium and short. Rice grades are measured by the proportion of whole grains in the sample; freedom from foreign material (stones, dirt, plant parts and animal droppings), weed seeds, stack burn and grain colour. Grades are assigned to delivered rice according to how well the sample matches the standards.

Post-harvest grain breakage

All rice varieties are predisposed to varying degrees of cryptic damage, that is grain breakage that shows up after the crop comes in from the field.

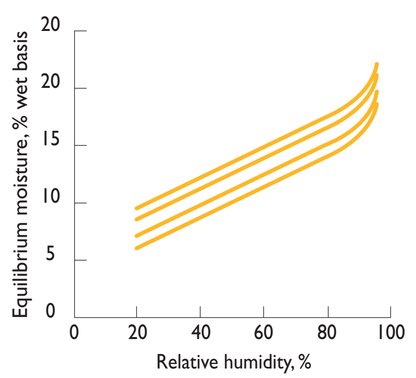
Harvest delays and wetting and drying cycles exacerbate the problem. During drying, handling and in the milling process, the grains break due to hidden cracks in the rice kernels. Add to this rough treatment in threshing or conveying and the result is broken grain, dockage and reduced premiums. Indica varieties, which have longer grains, are more inclined to breakage than the more rounded Japonicas.

Effect of harvest delays

Diseases and micro-organisms can cause paddy to deteriorate. Rice quality standards define the limits on the amount of grain that is discoloured, musty or sour and otherwise is of distinctly low quality. As the season draws on there is an increased risk of rain and a lower millout. The Ricegrowers' Association assesses dockage (depending on severity up to 50% of final pool return), based on appraisal laboratory sample analysis for stack burnt paddy; that is paddy that is obviously discoloured.

Discolouration occurs due to heat damage from being held too long in unaerated containers such as field bins, being left too long in the field and gaining moisture through rain, dew and fog.

FIGURE 1 Equilibrium moisture content



Source: ASAE Standards, D245.4 Dec 93.

FIGURE 2 Paddy grain components

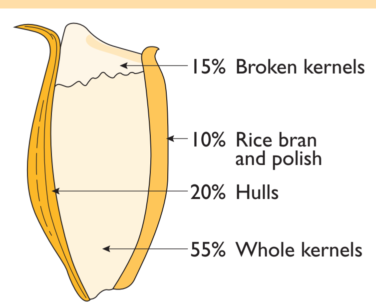


FIGURE 3 Fissuring of kernels

Kondinin Group

Fissuring of kernels occurs after drying and then exposure to a humid environment. Exposure of grain samples to a 100% RH environment can cause multiple fissures over time (Lan and Kunze, 1995). These fissures lead to broken grains which in a variety like Amaroo will be penalised below 40% whole grain (WG) on a scale to zero WG (penalty $40/t).

Ways to reduce trash in the bin

Kondinin Group

Two Case 2188 harvesters, one fitted with a stripper front (left), the other with a conventional front. Research has shown gathering losses to be higher with a stripper front, but in most instances higher capacity and lower operating costs make up for the losses.

Trash is extraneous matter which comes in from the harvest field and may cost the Australian rice industry more than $5 million a year.

This is due to the extra costs incurred when transporting, storing and drying trash, the outlay for trash delivered, the effects of trash on stored paddy quality and reduced milling capacity. In the 1997 season a project carried out by the Kondinin Group and Ricegrowers' Association investigated the causes of trash and ways to reduce it. The key findings can be found in Table 1. Field factors significantly affected trash levels. First and foremost was degree of lodging, then grain moisture content, rice variety and location. Harvest delays also exacerbated trash problems. Trash levels rose later in the season as the grain moisture content declined, but whether it was time in the season or moisture alone that affected trash was not determined.

A reliable trash-measurement technique at the platforms would better alert farmers to pay more

TABLE 1 Sensitivity of trash to various factors

	Days (N) from time of maximum FY	Low	Moderate	Highly influential
Crop/enviromental	Variety		■	■
	Moisture content			■
	Extent of lodging			■
	Harvest timing			■
	Weediness		■	
	Geographic location	■	■	
Machine	Machine make and model		■	
	Machine type	■	■	
Operational settings	Forward speed		■	■
	Fan setting			■
	Sieve setting	■		
	Drum/rotor speed	■		■
	Concave setting	■		
	Front height	■		
	Reel speed	■		

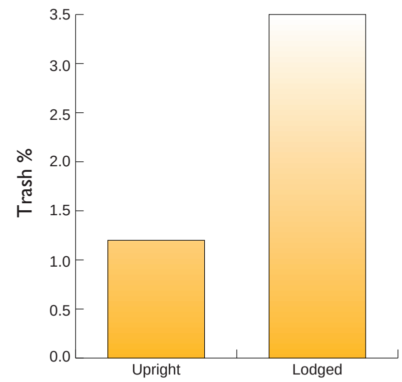
Kondinin Group

Kondinin Group researchers collecting material other than grain (MOG) after harvesting with a Case 2188 fitted with a Shelbourne Reynolds stripper front.

attention to trash at the harvester. 'Tails' (pedicels) on good grain present a dilemma. Up to 5% of the medium grain Amaroo samples had tails attached. The entire paddy handling system is affected by tails on good grain. Some of this is discharged as trash and some good grain is lost. Many of the old New Holland harvesters are still at work; they have a large cleaning area but throughput may be restricted by things such as engine power or gathering width.

Higher loss levels may explain why earlier models produced a cleaner sample than late models (see Figure 6). On the other hand, one of the best overall performances in terms of low trash, high capacity with low processor grain losses and satisfied operator was a 22 year old White 9720/ S-R stripper front combination.

FIGURE 1 Effect of lodging on trash levels



These effects were found across all brands and models

Stripper fronts

Data sampled from 1997 harvest have indicated that harvesters with stripper fronts had about 0.5% higher trash than harvesters equipped with cutterbars. This was found across brands and models.

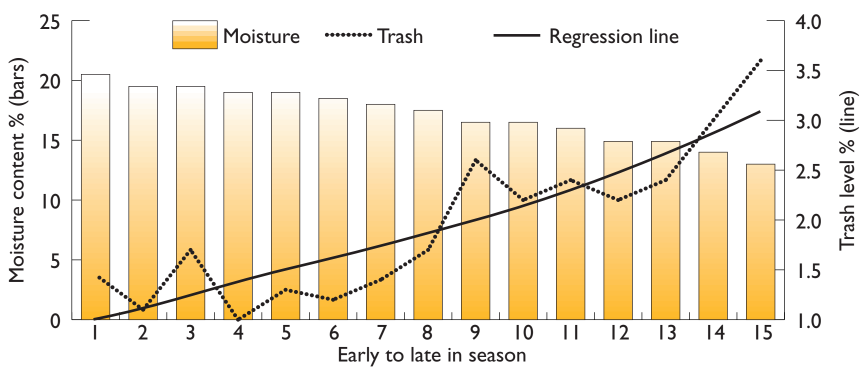
Operators reported that stripper fronts facilitated operation in lodged crops, enhanced throughput-loss performance of walker-type machines and performed better than a cutter bar in windy conditions.

Strippers allowed use of raspbar drums, which removed the need to change components between different crop types. It has not been determined fully whether this reduces trash.

But gathering losses were always much higher with a stripper front than the cutterbar. For example, in upright crop gathering losses were around 1.5–3.5 % when using stripper fronts and 0.5–1% when using cutterbars. Losses at the in-crop edges of the two brands of strippers were severe in lodged conditions if dividers were damaged or missing.

The problem of gathering losses with stripper fronts needs to be addressed and there is a need for stubby or flexible crop dividers on rice fields. In wheat, stripper fronts can thresh up to 98% of the grain at the front in dry conditions. The crop wall ahead serves as a curtain to keep grain from spitting out the

FIGURE 2 Grain moisture and trash levels



Measured over a period of one month, between late March and April 1997, variety Amaroo. Exponential regression line.

FIGURE 3 Effect of rice variety on trash levels, 1996 harvest

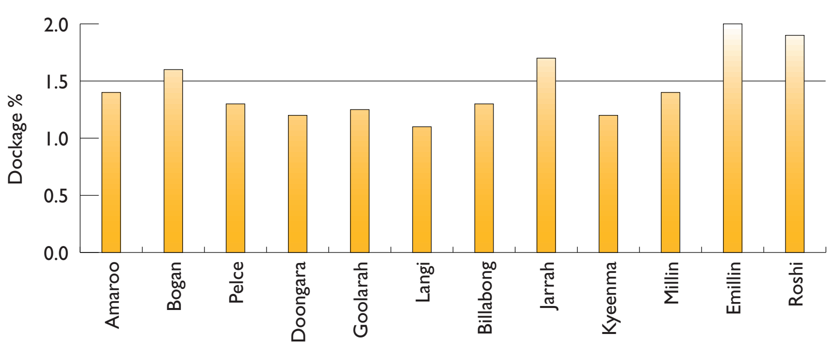
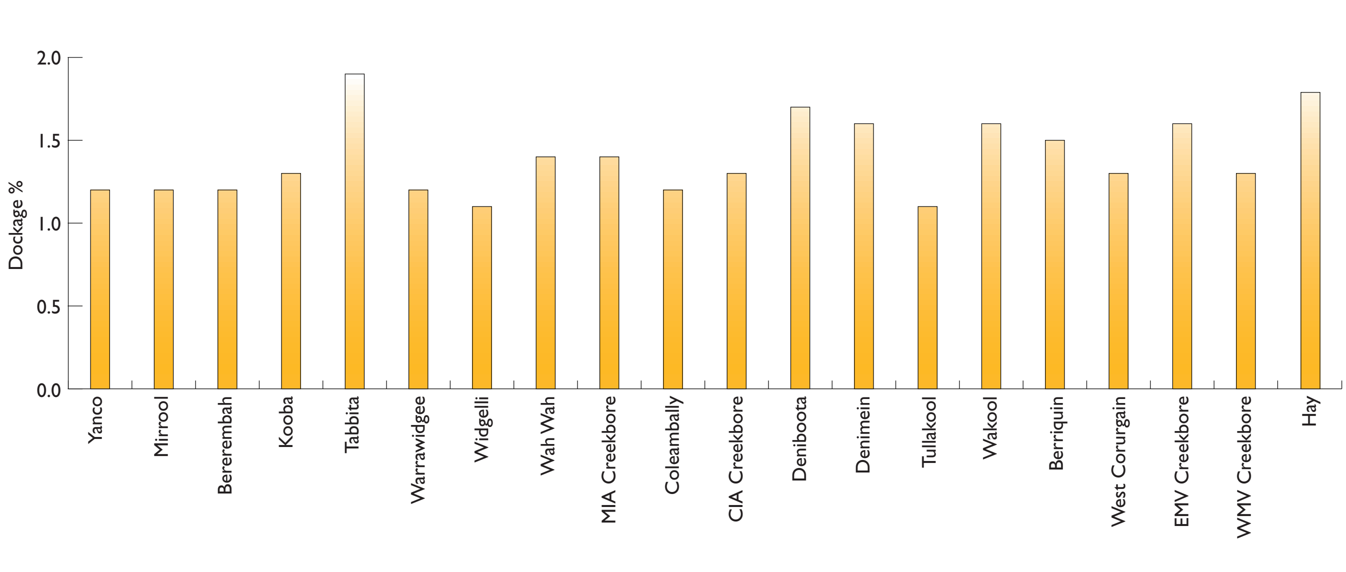


FIGURE 4 Varying trash levels in different districts



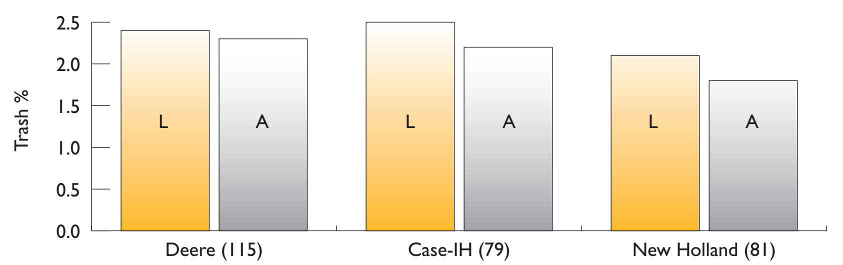
front — and therein lies a generic problem with the stripping principle in drier cereals and light crops.

Despite a stripper front's capability to almost double harvester capacity, lower the fuel consumption and reduce wear of processor components under the right conditions, some rice growers leave their stripper front in the shed for the wheat crop, preferring the cutterbar front to keep down grain losses.

Cleaning system performance

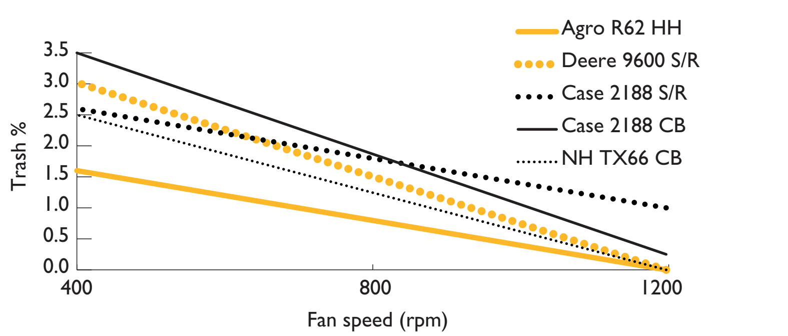
Of all adjustments, fan speed was the most sensitive factor on trash levels. The higher the fan speed, the lower the trash. Lowering fan speed only 300rpm could lead to a doubling in trash level with some harvesters. Sieve settings were not so sensitive. Cylinder speed and concave settings greatly affected degree of pearling (paddy dehusking) but were not highly sensitive on trash.

FIGURE 5 Effect of harvester-type on trash levels



These trash levels were measured from sampling 275 deliveries in the 1997 season, in varieties Amaroo (A) (medium grain) and Langi (L) (long grain).

FIGURE 6 Fan speed and trash levels



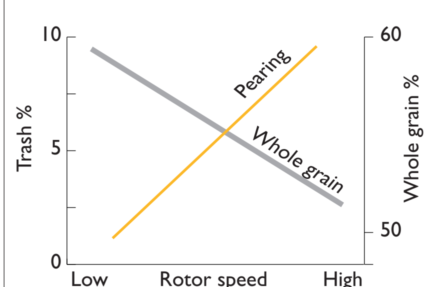
Pearling increased sharply with higher cylinder or rotor speed and whole grain millout declined accordingly.

How to reduce trash

Project sampling from trucks at delivery indicated an average level of 2.23% trash in loads, which amounts to more than 30,000 tonnes of trash. This much trash could take the space of over 100,000 tonnes of paddy.

Trash can be reduced by careful selection of varieties, crop management to avoid lodging, then harvesting early or minimising delay. Attention to details in machine operation helps, such as keeping up fan and forward speeds consistent with acceptable levels of loss. Mind that the cleaning system is not overloaded otherwise excessive trash will show. Get feedback from the receival platform operator with each delivery to pinpoint harvester adjustments that need to be made to keep trash levels down. Organic trash originates on the farm — the best place to leave the trash.

FIGURE 7 Rotor speed and pearling



Tests carried out on Pelde variety, harvested with a White 9720 harvester. Unlike pearling, changing rotor speed had a minor effect on trash levels.

Managing field operations

Two criteria are used to arrive at a specific harvest cost: material processing performance and economic performance.

$$\text{Unit harvest cost (\$/t)} = \frac{\text{Economic performance (\$/h)}}{\text{Material processing performance (t/h)}}$$

Or alternatively,

$$\text{\$/tonne} = \frac{\text{Total harvest cost, (\$/year)}}{\text{Tonnes harvested per year}}$$

Kondinin Group

Ongoing monitoring of a harvester's material performance and economic performance is essential to minimise costs for maximum harvest benefit.

Material performance

Material performance is tonnes/hour of grain or crop throughput at acceptable loss rate. For rice, ASAE's recognised standard is 3 per cent total machine loss. See Figure 1 for the typical shape of a harvester performance curve. The point on the curve where the aggregate machine losses exceed 3% is the cut-off for establishing the performance rating.

The harvester can be operated at a higher loss level, but a good manager will clamp down on an operator to set the machine to get losses down below the critical 3% line. An operator may be required to slow down, readjust machine settings or look for a malfunction. In a rice field the most crucial factor governing processing losses is usually the amount of straw or MOG intake.

Assessing field efficiencies

Field efficiency is the ratio of the effective capacity of a machine or machine system to its theoretical capacity.

Field capacity of a harvester is measured on an area basis in hectares per hour, or by throughput in tonnes per hour (this usually refers to tonnes of grain, but in some cases total material throughput is of interest).

Effective field capacity is a measure of actual sustained performance over a day or a season. By comparing that with the theoretical field capacity it discloses shortfalls from the ideal. Shortfalls include the difficulty of continuously operating at spot rates or top performance, of keeping the gathering front full all the time, of getting the grain out of the field at a rate matching the harvester. It also focuses on time-consuming and unproductive activities due to machine and management problems, such as the weather and operator time-out.

Field capacity is measured on an area basis or a throughput basis.

$$\text{Effective area capacity } C_a \text{ (ha/h)} = \frac{S\ w\ E_f}{10} \quad \{1\}$$

where S = forward speed, km/h.
w = machine working width, m.
Ef = field efficiency, decimal.

Or, alternatively:

$$\text{Effective material capacity } C_m \text{ (t/h)} = \frac{S\ w\ y\ E_f}{10} \quad \{2\}$$

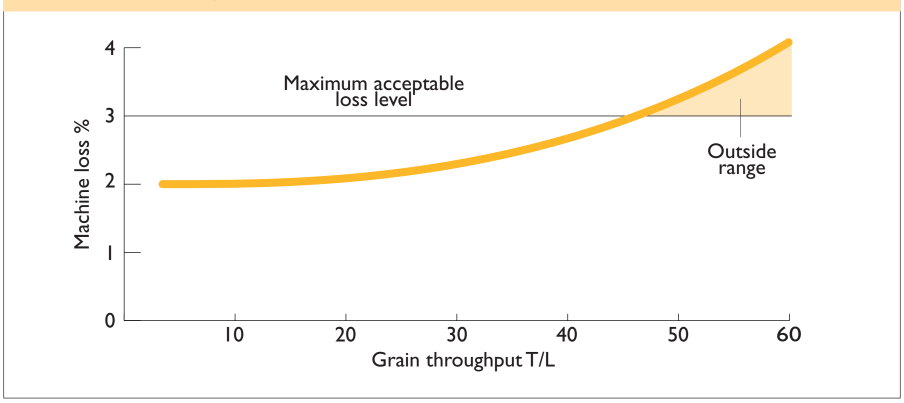
10 where y = field yield, grain t/h

Field efficiency (Ef) is the ratio between the machine's productivity under actual working conditions and the theoretical maximum possible productivity. For a large modern self-propelled harvester Ef is typically around 70%, (Ef = 0.7) or for less efficient equipment or worn-out harvesters, around 60% (Ef = 0.6).

$$\text{Operating area per day } A_d \text{ (ha/d)} = \frac{Ca\ h\ k}{100} \quad \{3\}$$

where Ca = Area capacity, ha/h, as in {1}
h = hours worked/day.
k = time efficiency, %.

FIGURE 1 Harvester performance curve



$$\text{Area per year } A \text{ (ha)} = \frac{(D-R) \times A_d}{N} \quad \{4\}$$

where D-R = Typically 25, that is the days available per season minus days when operation is not possible.
N = Number of repeated operations (usually 1.0 for direct harvesting).

Selecting machine capacity for a given area:

$$\text{Required machine capacity } C_1 \text{ (ha/h)} = \frac{A}{BG \text{ (pwd)}} \quad \{5\}$$

where A = Area to be harvested, ha.
B = number of days required to complete harvest.
G = anticipated time in hours available for field work each day.
pwd = decimal probability of a full working day.

Most lost-time factors can be reduced with advanced planning and management. The more expensive the harvester, the more expensive are any blunders in management and the greater the savings that can be made by paying attention to detail.

TABLE 1 Factors affecting efficiency and causing lost time
Travel to or between paddocks.
Servicing and fuelling the harvester.
Type and condition of harvester.
Field conditions, field shape, access and size.
Crop yield and condition.
Operator skill, experience and acuity.
Machine manoeuvrability.
Turning and field patterns.
Unused capacity.
Number of harvesters in use.
Unloading procedures.
Unplugging the harvester.
Making adjustments.
Repairing breakdowns.
Rest breaks.
Changing operators.
Checking machine performance.
System limitations such as unmatched machines and long haulage distances.


John Deere

Corner post instrumentation — John Deere.

In rice fields, time lost in turning and manoeuvring can be more than half of total field time. This can be modified by planning field layout to shape the bays to better suit the harvester.

For example, bay width should permit a full comb each run and bay length chosen to allow the truck or bin to be placed at a distance where the harvester bin will have been filled. Stopping to unload a Class 6 harvester can amount to more than 15% of field time. Chaser bins eliminate the costs of stopping to unload but their costs need to be factored into the overall system.

Keeping records

A good manager keeps careful records of a machine's performance correlated with machine hours. There are large savings to be made by considering carefully each of the above issues to obtain the highest possible field efficiency and system performance.

A log book should contain the following for financial management, operator performance, security and taxation purposes:

- Machine details.
- Parts replacement record.
- Recommended lubricants and fuels.
- Services record.
- Monthly cost summary.

Machine systems

The harvest operation typically involves a system of machines in which the field efficiency of any one machine may be the limiting factor on the capacity of the whole operation.

Suppose the rice mill or receival centre has a handling capacity limited by the pit elevator at 80 tonnes of wet grain an hour. Grain delivery trucks bringing in more than this will be delayed and this has repercussions leading back to the transport wagons or chasers and even to harvester operations in the field. This becomes highly relevant to harvesters capable of harvesting over 40 tonnes an hour.

A cycle diagram or flow chart helps to clarify a system's performance evaluation. The longest cycle time in the system — be it the harvesters, transporters, or receival centre will govern the overall system cycle.

Computer simulation models can be valuable to help high-cost practitioners lower their unit costs to compete with the more efficient operators.

Field patterns — opening the field and turning

Turning time is a loss factor common to all field machine operations — sound planning involves making turns without slowing or using extra motion to line up the next cut.

If there is not enough space at the end of the run for a continuous turn and backing is required, turning time may be doubled. Turning time can be 50 per cent or more of total field time in rice bays, because rice bays are by definition smaller parcels of land. Even on an extensive rice farm, the maximum size of a bay is restricted to around 10 hectares due to the effects of wind.

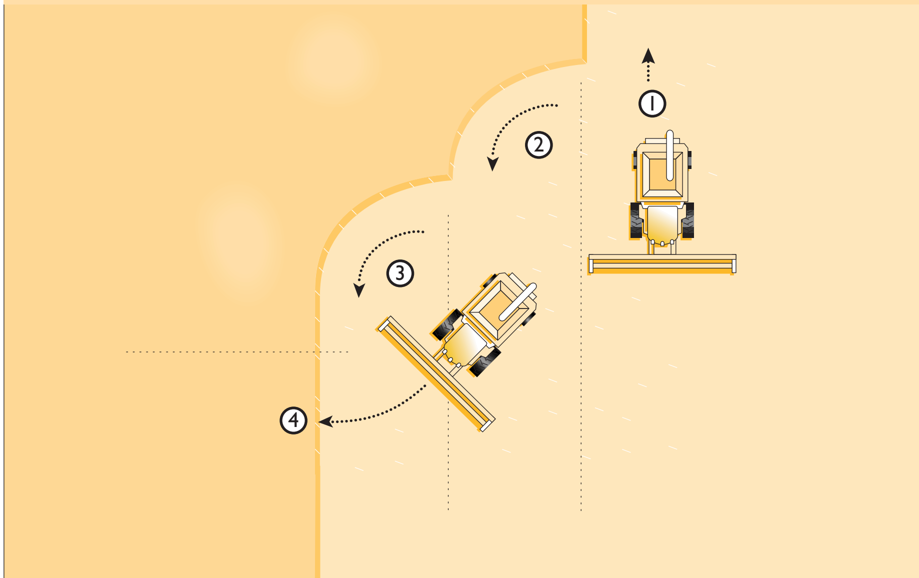
Turning compromises

Operators of harvest equipment face a compromise in the way they tackle a given parcel of crop.

Several driving and turning patterns are possible, and the sharpness of any turn is dictated by the harvester's turning radius and whether turn brakes are used. The trade-off between different turn styles lies between the time each will take, whether unharvested bits are left, swiping down some crop and operator preference.

On the opening round, carry out travel in an anticlockwise direction. This is necessary because harvesters usually have a slim crop divider on the right side and an unloader spout on the left side; on an older machine the unloader would be manually extended and left out once in the field. With closed-turret hydraulic swing-out unloaders there is more flexibility. These features enable the operator to drive closer to the edge and avoid the risk of the unloader spout striking any obstruction such as trees or power poles along the edge of the field. Successive rounds are then made in the opposite direction, with the unloader on the side that was cut. To make the first turn into uncut crop and minimise running down the crop, see the pattern shown in Figure 1.

FIGURE 1 First turns and corners

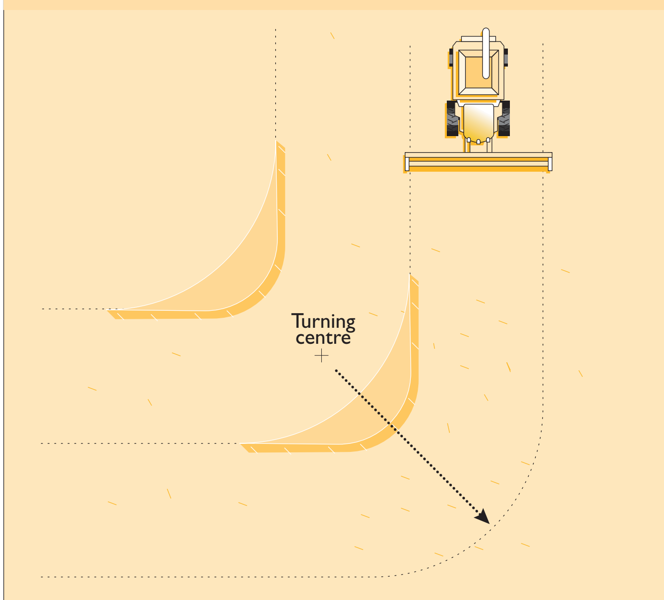


Drive up to the corner, stop and back up one machine length, turn 30° and then harvest a machine length. Repeat the procedure until the necessary turn has been made. The first round made is anticlockwise.

Field size and turning time

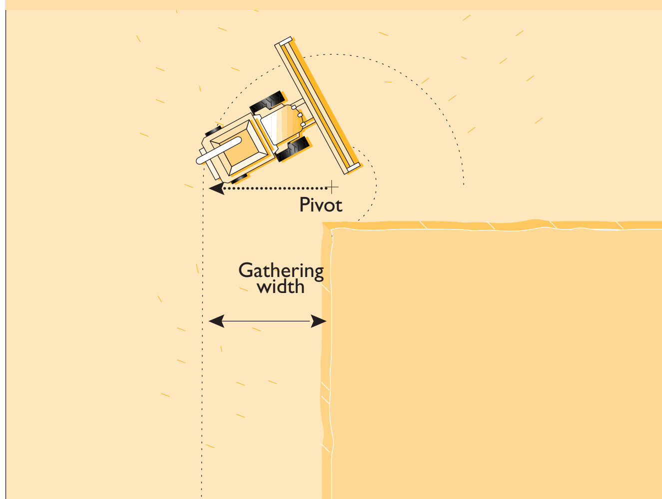
Field size is critical in rice farming due to the small size of bays. Figure 6, page 28, shows how field size can have a large effect on pattern efficiency.

FIGURE 2 A continuous 90° turn



Manoeuvres to open the first corner include backing one machine length and making a 30° turn.

FIGURE 3 90° turn showing radius



ASAE standards define the turning radius of the harvester as the radius of curvature from the effective turning or pivot point to the centre of the outside drive wheel without using the turning brakes. For Class 6 harvesters the turning radius is between 6–8m, or close to the same as the width of the gathering front for that size rice harvester.

FIGURE 4 Machine turning patterns

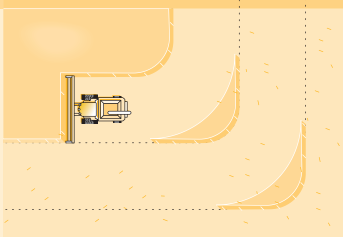
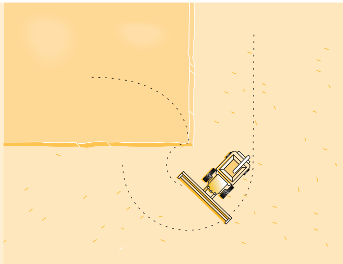
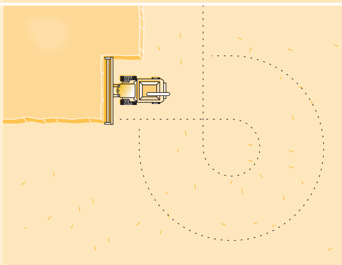
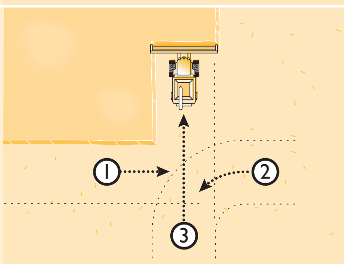
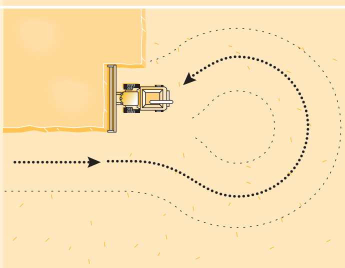
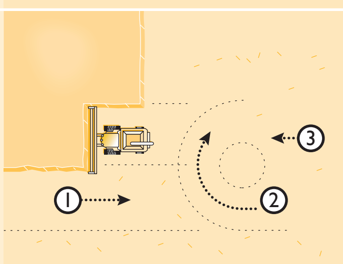
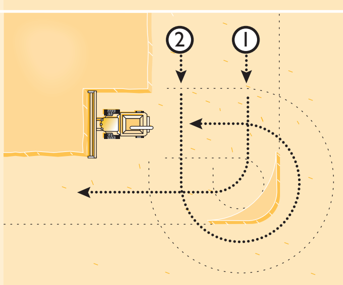
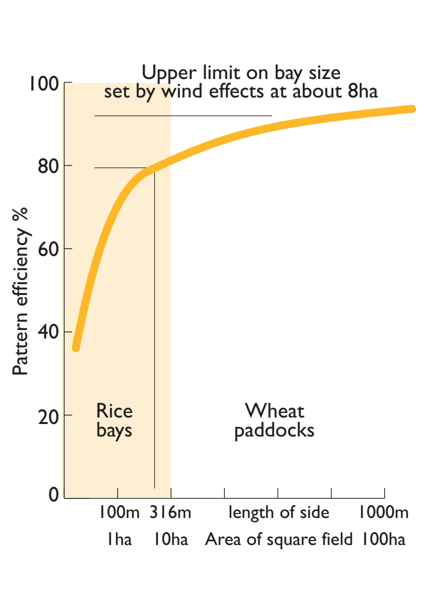
Type of turn	Illustration	Advantages	Disadvantages
1. Continuous 90° or crescent corner.		No speed change needed if machine not moving too fast, eg below 5km/h.	Turn swipes down some crop on inside on run. Leaves unharvested crescents, needing cutout
2. Continuous 90° or in and out turn		No speed needed if machine not moving too fast, eg below 5km/h.	Imperfect corners. Swipes down some crop on inside of run. Leaves some crop unharvested even if turn brakes used to tighten turn.
3. Continuous 270° or loop turn		Perfect square corners possible. No speed change needed if machine not moving too fast.	Requires a headland. Takes more time - slowest type of corner manoeuvre.
4. Reverse turn		Perfect square corners possible.	Requires a headland. Must stop to reverse. Takes time. Harder on transmission.
5. Continuous 180° or semi-circular end turn. Maybe symmetrical or asymmetrical		Can fit in with unloading cycle.	Requires a large headland. Takes more time. Need care in lining up next cut.
6. Reverse 180° end turn		Useful where space insufficient for continuous turn.	Requires a headland. Takes 50% more time than continuous 180°
7. Combination of crescent and loop corner turns alternated		Can be used to cut out the crescentric bits without separate operation.	Needs more driving skill.

FIGURE 5 Field size and pattern efficiency



When bays are less than one hectare in size, more than half the time can be absorbed in turns.

Small bay sizes disadvantages rice harvest operations compared with other crops or broadacre farming. In practice rice bays are rarely square but are often elongated rectangles or lengthy serpentine strips following field contours.

Different turn styles

Three field pattern options are:

- Round and round, peripheral, or circuitous.
- Sectioned or headland.
- Backwards and forwards, or side-to-side.

Of the several field patterns possible, each has drawbacks and advantages depending on the actual field shape, whether the particular field can stand repeated vehicular traffic, location of bins, crop yield and proximity to access roads for grain trucks.

Initially, the shape of the field will dictate the field pattern, but an operator also can choose to harvest a field to suit the pattern best matched to his overall farming system. Out-of-crop time must be factored in an efficient operation.

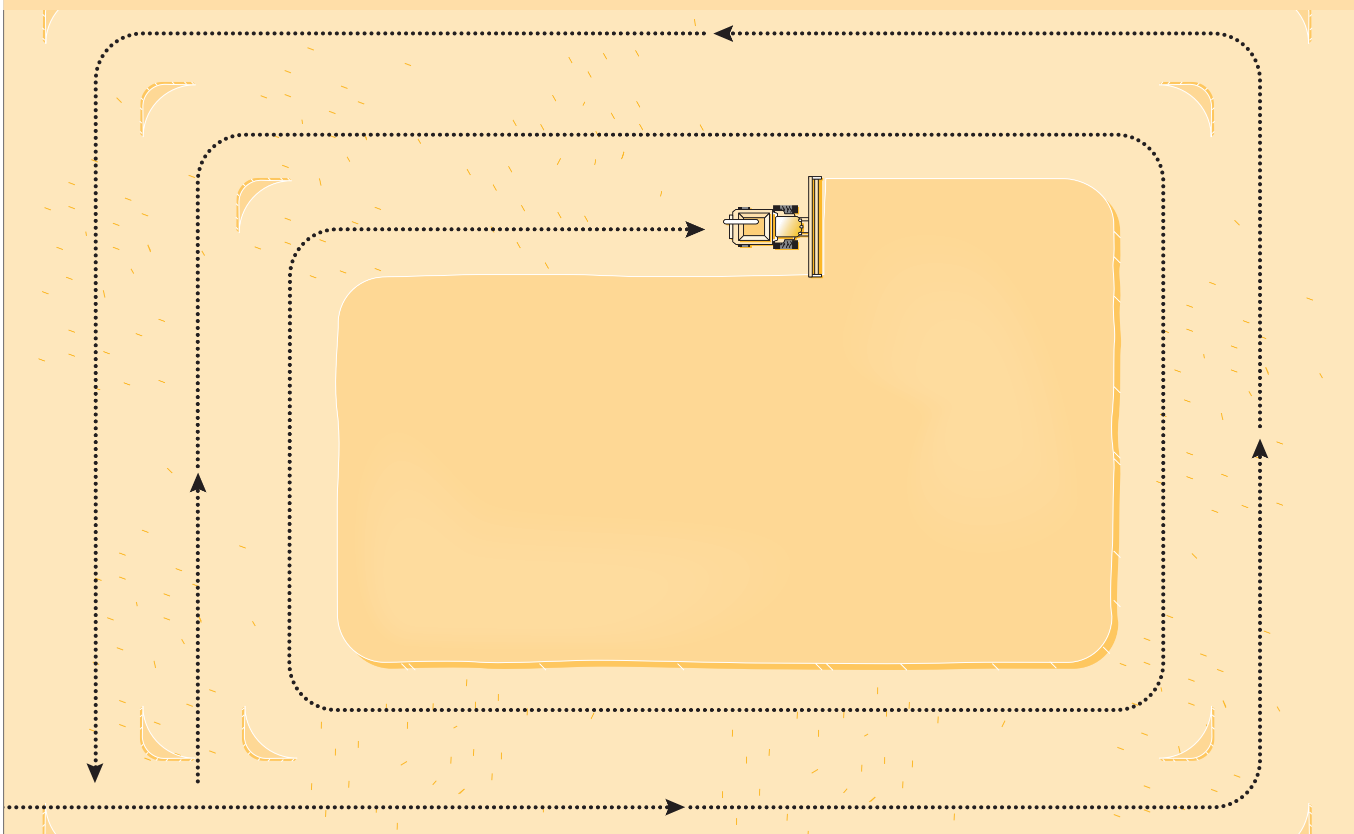
Rounded corners

Harvesting round and round a rectangular field with 90-degree rounded corners would appear to have the greatest field efficiency, but a crescent-shaped area is left at each turn. Some crop is also knocked down at the turns and additional work is needed later to take off the unharvested crescent pieces. A drawback of this pattern is that in a large field the harvester bin will fill at different positions distant from the collection point or field bin. This is not a problem if unloading on the run and using two-way radio contact to ensure the driver with the chaser bin or bank-out is at the right place when needed. This is reliant on the field surface being able to support a tractor and heavy chaser bin.

With modern harvesters which have the unloader spout on the left side, the first round is best done anti-clockwise with subsequent rounds in the opposite direction. The round-and-round pattern works well in conjunction with on-the-go unloading and makes it easier where the straw trails are to be subsequently baled, slashed or burned.

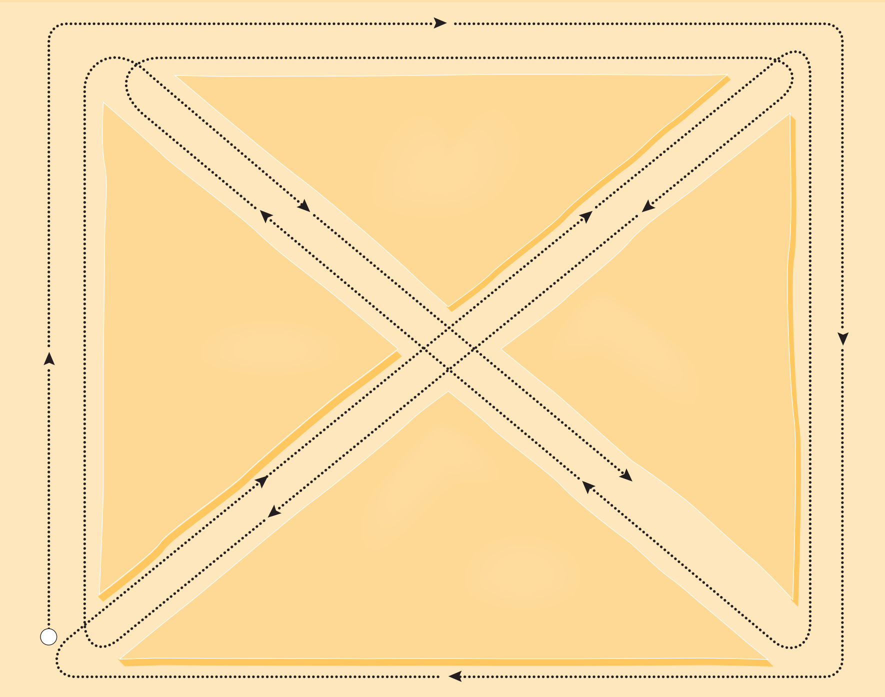
An efficient field pattern is one that minimises the amount of field travel, reducing non-productive use of valuable machine time and fuel. If more than one harvester is operated in the same field, the peripheral pattern is the better approach, but if the

FIGURE 6 Round and round, peripheral or circuitous pattern with rounded corners.



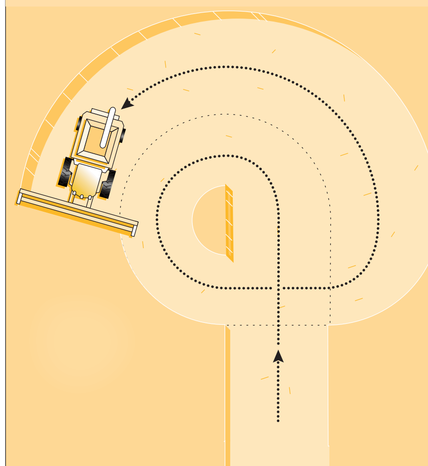
Cutting our diagonals after completing the first rounds on the periphery. This mode of operation reduces swiping down the crop at the corners, but is a drawback if the straw is to be subsequently baled.

FIGURE 7 Cutting out diagonals after completing the first rounds on the periphery



Drive up to the corner, stop and back up one machine length, turn 30° and then harvest a machine length. Repeat the procedure until the necessary turn has been made. The first round made is anticlockwise.

FIGURE 8 Opening field centre



Opening the centre of a large field to made space for a collecting station or mother bin where field conditions permit traffic.

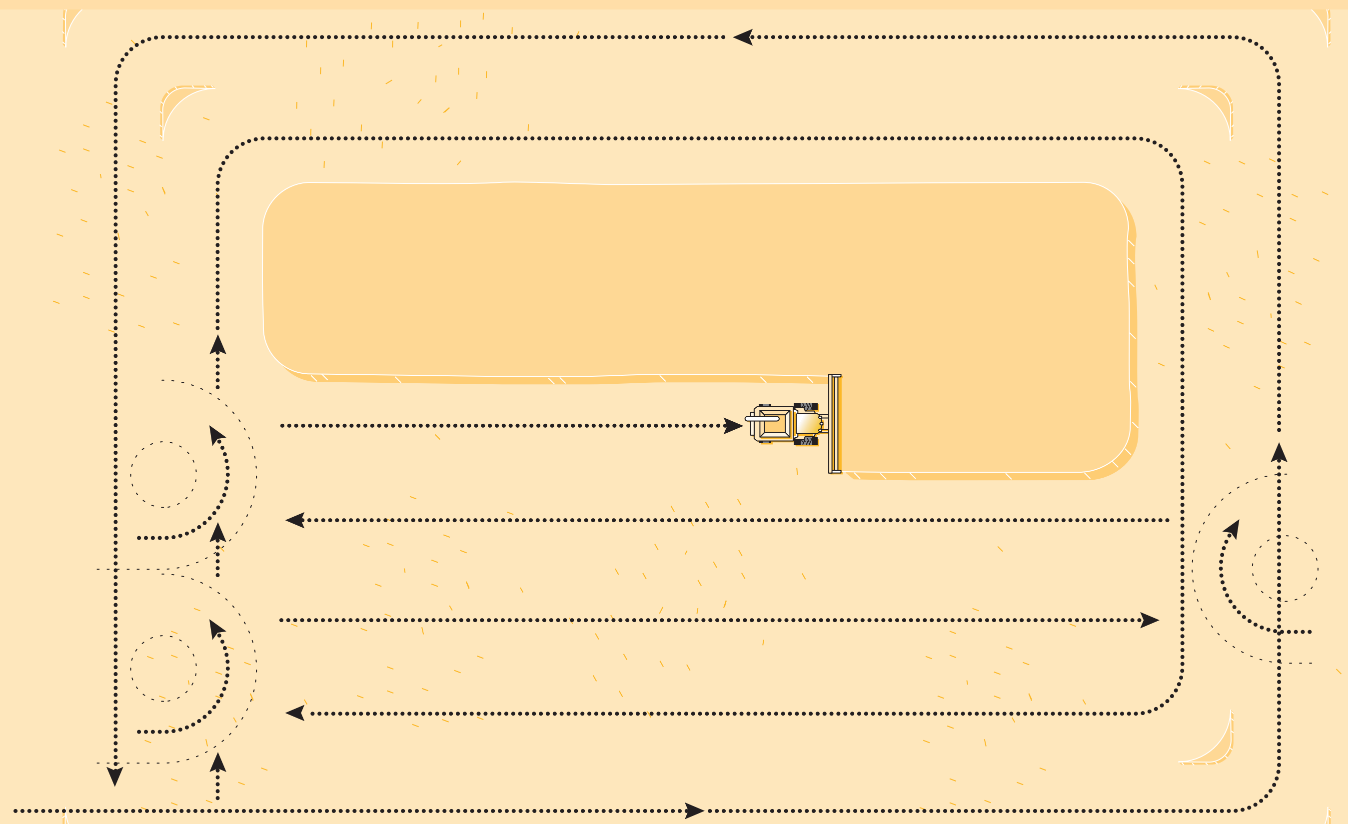
machines do not operate at the same forward speed, the higher capacity harvester should go ahead of the others.

The shape of rice bays is dictated usually by water management considerations. Before laser levelling became prominent, contouring was practised. Now earthmoving equipment can reform the bays to better suit an area, improve water use and improve field equipment management.

Field shape and efficiency

Elongated fields are more efficient to harvest than square field shapes, as pattern time efficiency improves markedly with length, see Figure 9.

FIGURE 9 Backwards and forwards, side-to-side or reversible field pattern



This pattern is used after a couple of peripheral rounds. The pattern ensures a full cut on most passes, but requires time-consuming 180° turns.

Irregularly-shaped fields with headlands at an angle to the cutting width lower efficiency — the turn is longer and area and motion are wasted compared with rectangular shaped fields, see Figure 10. For example, when comparing two irregular fields, the shorter field, 122 metres on the longest side, had 20% turn time; the machine could cover 0.8ha/h versus 3% turn time and 1.2ha/h field capacity for the field with longest side 323m — a 53% increase in field capacity for the same field operation.

Rice bays are rarely square, being most often elongated rectangles or lengthy serpentine strips following contours.

Unloading

Stopping to unload a harvester can consume up to 15% of field time.

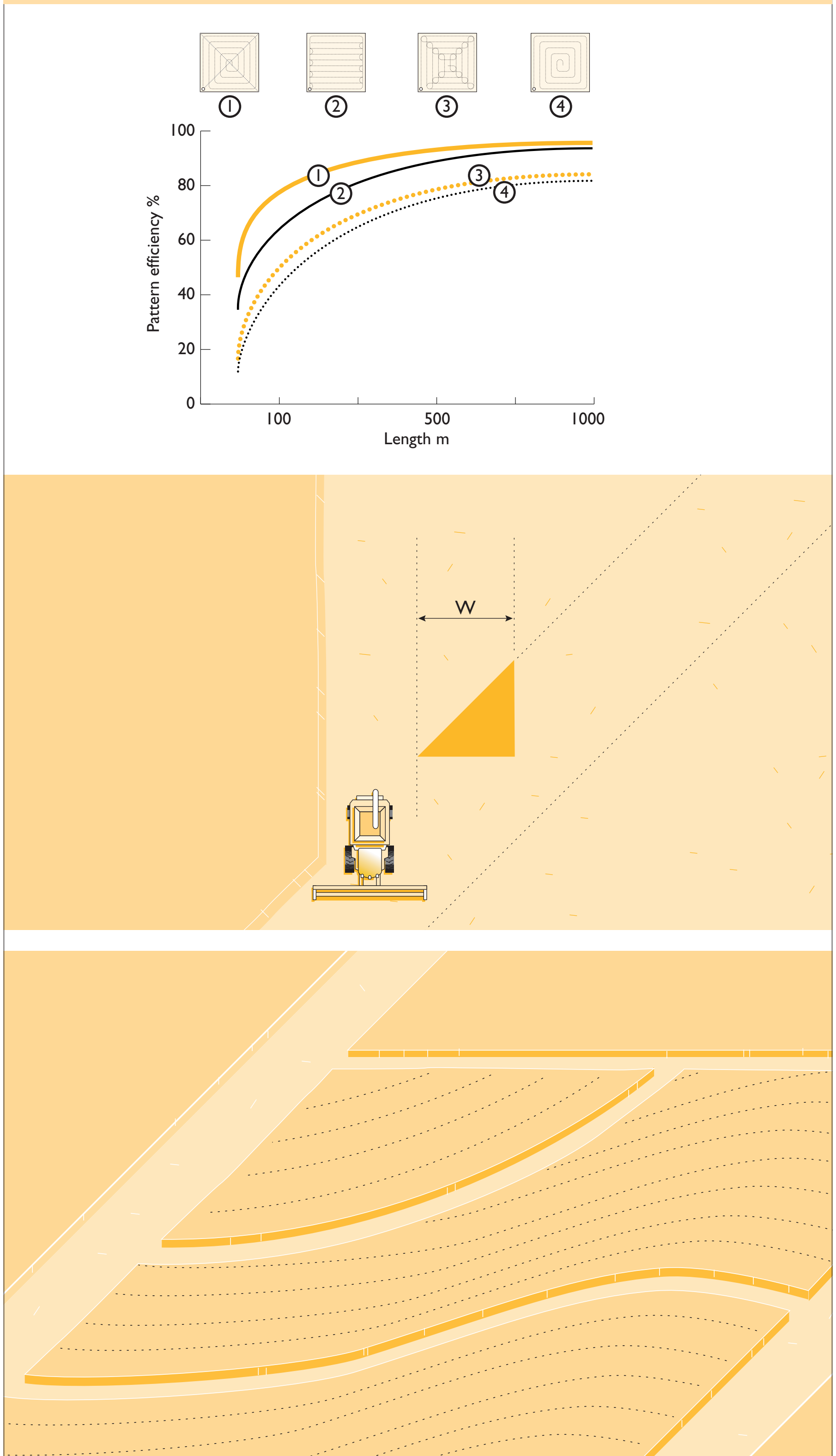
Unloading on the run into a follow-up transporter (known variously as chasers, grain wagons, bank-outs or haul-outs) eliminates time wastage, but requires coordination and radio contact with the driver of the chaser bin.

If chaser bins are unavailable then there is the need to balance field size against yield so that ideally, the harvester makes a whole number of rounds to the starting or collection point with the harvester bin just filled.

Irregularly-shaped fields and small rice bays each pose their own challenges. Field efficiency in odd-shaped bays and around obstructions is considerably less than for plain rectangular parcels. As the harvester is not operated at optimum load all the time then second-cutting of stubble and trash levels increases.

Operators usually figure out a strategy on the spot; the aim is to minimise out-of-crop time, maintain a full cut and maximum uninterrupted length of run.

FIGURE 10 Irregularly-shaped fields and rice bays



These curves show the effect of types of turns on efficiency and were plotted from calculations taken in fields in Illinois, US. Pattern efficiency equations were applied with the following assumptions: field length equals width; turning speed equals harvesting speed; gathering width equals 6m; turn swing radius equals 2w; headland width equals 4w.

In brief

- The harvest and transport component can exceed 40% of a rice grower's field costs.
- There is considerable scope for making meaningful reductions in unit costs.
- On rice fields the bays are small and manoeuvring time large; harvest management and selection of suitable field patterns are more critical than with other cereal crops.
- Planning ahead and modelling the system will lower costs. Compare field management approaches and the pros and cons of different field operational styles.

Costings — ownership vs contracting

Informed decisions on whether to buy new or used, to hire or lease harvest equipment or bring in a contractor, repair or replace, and indeed make any capital changes in the farm enterprise can only be made if good records or advice are available.

The example in Table 1 shows how to calculate owning and operating costs and contract rates for a harvester. Space in the far column has been left for your own calculations.

Total machine costs are the sum of two categories of costs: ownership and operating.

There are several critical factors governing unit costs. Hours of operation and amount of crop to harvest are the most readily affected by management choices in a given season.

For the combine example above operating at an average of say 20 tonnes/hour over the season;

Unit cost = $11. 82/tonne

Figure 1 shows the ownership and operating costs of 36 Australian rice harvester owner-operator's using their own reported 1997 records for a regression of unit costs against average throughput.

Figure 2 shows calculated ownership costs compared with two contracting rates, $22.50 and $16.50 per tonne of wet grain on Australian rice fields for a Class 6 combine. Many farmers prefer gauging performance in tonnes of grain per day or per season rather than in machine hours.

The effect of annual hours of use on costs is shown clearly in this plot. But note that for a fixed crop area,

FIGURE 1 Ownership and operating costs

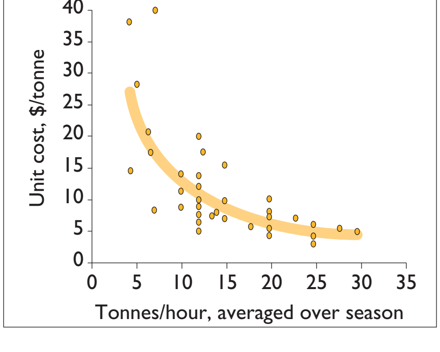


TABLE 1 Calculating ownership and operating costs

Fixed, or ownership costs.					
These apply whether the machine does any work or not. Included are depreciation, repairs and maintenance, taxes, insurance, interest charges and machine storage-related costs.					
Purchase cost (PC)	$250,000				
Anticipated hours of use	2000 separator hours use in 5 years.				
Trade-in or resale value (RV)	$117,500 (47% of PC).				
Calculated average value (AV)	$250,000 + 117,500 / 2	= $183,750.		=	
Annual interest cost @ 15%/y	$183,750 @ 7.5%	= $13,781.25.		=	
Interest cost per hour	$13,781.25/400	= $34.45/h.		=	
Annual depreciation (Using straight line method)	$132,500 / 5	= $26,500/y.		=	
Percentage depreciation	100 * $26,500/$250,000	= 10.6%/y.		=	
Hourly depreciation	$26,500/400h/y	= $66.25/h.		=	
Insurance at $10 per $1000AV	$183,750/100	= $1837.50/y.		=	
Insurance cost/hour	$2500/400	= $6.25/11.		=	
Housing or shedding cost @ 1% PC	$250,000/100	= $2500/y.		=	
Shedding cost/hour	$2500/400	= $6.25/h.		=	
Registration and workshop costs		= $2500/y.		=	
(Calculated here also @ 1% PC)		= $6.25/h.		=	
Business overheads as a contractor, $ 2800 notional		= $7.00/h.		=	
Total ownership/fixed or overhead costs		**= $124.79/h.**		=	
Variable operating costs.					
These vary according to machine usage and include operator wages, fuel, lubricants and expendables:					
Fuel costs 40 litres an hour @ 0.55/litre	40 * 0.55	= $22,00/h.		=	
Engine oil cost 25 litres @ $2.50/L every 250 hours		= $0.25/h.		=	
Lubricating, cooling and transmission fluids					
$3.00/L * 1001 changed @ 400h.		= $0.75/h.		=	
Filters $240 changed @ 250h.		= $0.96/h.		=	
Tyres forestry specials for rice		= $4.00/h.		=	
(One set in five years @ $9000).					
Batteries: one set in five years @ $300		= $0.15/h.		=	
Repairs and Maintenance					
(R& M @ notional 5% of PC)		= $4.75/h		=	
Operator (driver only) labour rate		= $25.00/h		=	
Total variable costs		= $76.86/h.		=	
SUMMARY					
Total fixed or overhead costs		= $124.79/h.		=	
Total variable costs		= $76.86/h.		=	
TOTAL COSTS OF OWNERSHIP		**= $201.65/h.**		=	
For contracting, further add profit and contingencies					
Calculated @ 25% of overheads		= $31.19/h.		=	
Contract rate per hour		**= $232.85/h.**		=	
This does not include the trucks, chaser bins and cartage costs involved in field work.					

machines with higher grain throughput performance will operate at a lower cost per tonne and per hectare, and the harvest will be completed in better time. With a fixed area to harvest, costs per hour of operation will actually increase, which is the situation if a combine is equipped with a capacity-enhancing stripper front. The key to exploit fully such an attachment is to find more crop to harvest in order to spread the cost over a larger number of hours and then capitalise on the extra performance.

Figure 2 shows the hourly costs of owning and operating a $190,000 rice harvester that works for 400 hours a year versus 150 hours a year.

Determining machine costs

A simple way to calculate repair and maintenance costs is to assign a fixed percentage over the life of the machine. A notional figure of 40 per cent of list price to cover total repairs and maintenance may be close to the mark for many harvesters.

In actuality these costs will change with time. Initial repairs may be carried out under warranty. Accounting procedures for depreciation and interest charges will be dictated by current taxation rules.

Calculating a working life

ASAE Standard D497.2 suggests 3000 hours as a typical working life for a self-propelled harvester.

Annual hours of use will determine the economic working life and the hours are usually substantially higher in Australia than the United States figure. Visitors to a vintage machinery show or field days can see machines aged 50–100 years which are still in a good state of preservation and operable. Harvesters will often be phased out as out-dated technology rather than due to wear and tear. There are several viable businesses dealing in or restoring second-hand harvesters for smaller-area operations.

$$\text{A basic rating, or average annual depreciation} = \frac{\text{Original machine cost - resale value}}{\text{working life in years}}$$

The resale or remaining value for North American harvesters is calculable as a percentage of original list price at the end of year n, as follows RV. = 64(0.885)n. (ASAE D497.2, 1995).

Managing and driving

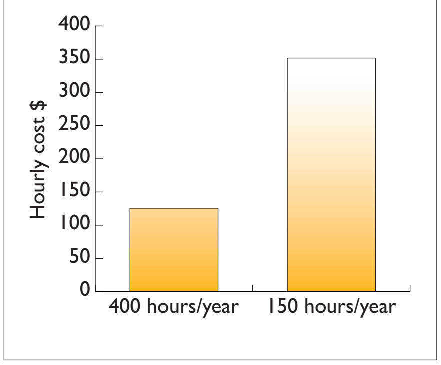
Ultimately, the purchase of farm equipment is decided on the basis of the farmer's cash flow situation, and then on which machine will provide the most timely operation.

A machine log on the number of hours of productive work in a given period of the field program is essential, not only for monitoring service work and costs, also when it comes to resale. Sample log sheets are shown.

In 1996, performance evaluations and surveys of harvester operators covered twenty different combinations of harvesters and fronts tested at five sites. This revealed that while the Class 6 and 7 harvesters were capable of performances of more than 35 tonnes of grain an hour and spot rates of more than 60 tonnes of grain an hour, seasonal usage by some harvester owners was as low as 6 tonnes an hour.

Often overall efficiency was barely 20% for the harvester for the season, that is 80% of the time the machine was not in the crop and not being used productively. The same study showed that harvest costs ranged from over $70 per tonne of grain harvested to below $7 per tonne of grain.

FIGURE 2 Hourly costs



Farmers' unit harvest costs escalated when the number of hours of machine use were low, the machine performance was inadequate and the operator did not use the full potential of machine hours in actually harvesting the crop, for example not keeping the comb full.

Figure 2 shows how the calculated ownership costs compare with contract rates. With the parameters chosen for a Class 6 harvester, a manager would need to harvest around 1700 or 2700 tonnes respectively in the season to be operating cheaper than the two quoted contract rates for 1996.

Tonnes instead of hours are used here for the lower axis — some operators prefer to log the tonnes of grain through the machine in a day or a season, rather than figure from the machine's hour meters.

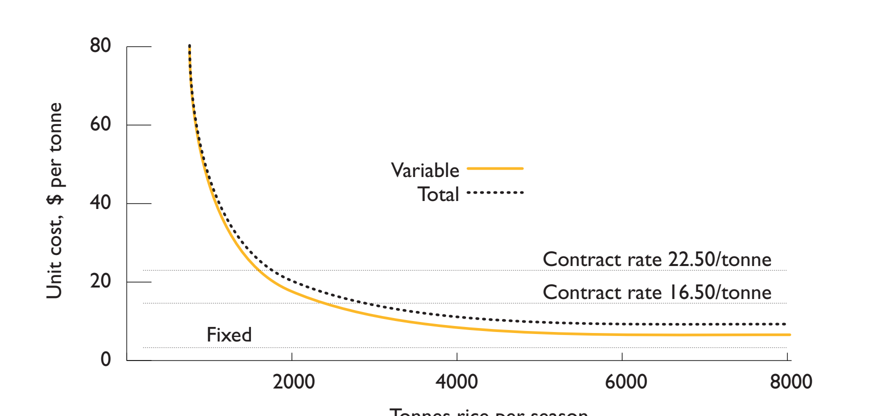
Leasing or purchasing

Leasing or renting equipment is one way to reduce operating costs.

Payments for renting or leasing may be fully deductible as a business expense. Renting is different from leasing in that it may involve short periods of time, while leasing is reserved for contracts that might be up to several years duration.

A lease contract cannot be breached by either party without recovery of damages, but is more attractive to farmers who are claiming investment credit or considering machine

FIGURE 3 Ownership costs and contract rates



Source : Quick et al, 1996.

purchase for a nominal sum at the end of the lease period.

Cost records

Systematic managers maintain operational cost records for machinery to provide the following:

- Legitimate income tax deduction expenses.
- Production cost data.
- Information on which to base equipment replacement decisions.

A rational basis for choice is needed when it comes to an investment in or replacement of an item as enduring and expensive as a harvester. There are five formal methods to compare as alternatives: payback period (PBP) and break-even point (BEP), which are undiscounted procedures; and the discounted procedures — benefit/cost ratio (BCR); net present worth (NPW); return on investment (ROI) or internal rate of return (IRR). The choice among methods is a matter of personal preference, corporate policy or will depend on taxation requirements.

Contracting over ownership

The largest new fully-equipped rice harvesters cost over $230,000 in 1996.

When financed over five years, the capital outlay is $305,000 with a $60,000 deposit and five yearly payments of $49,000. If the harvester does 1200ha each year; and adding the variable costs of around $19.50/ha, harvester ownership would cost $70.30 per hectare or, if over the years the crops average 7.5 tonne/ha, the harvest cost is $9.37 per tonne of paddy.

The 'official' contract rate to Australian rice growers in the 1996 season was $22.50 per tonne, wet weight.

Other options

The decision to hire a custom operator, buy, rent or lease a harvester, or even to join a machinery ring or syndicate, comes down to individual situations and practical considerations, some of which are not driven by economics.

A number of complex of factors are involved. Some of these include :

- The cost of finance, which may involve taxation measures.
- The timing and level of cash payments in relation to the cash flow of the enterprise.
- The security demands of the lender or lessor.

Summary

The rice grower who decides to buy his own harvester or transporters has to live with that decision for the next five to fifteen years or more.

When seen in this light, the matter of advising farmers on machinery operation and purchasing is worthy of greater consideration by institutions and government bodies. Individual ownership or leasing requires the local skills to operate, service and maintain the harvester.

Machine leasing may be a good option for an expanding business short on capital, but with good prospects and management skills. Leasing involves making a large initial payment then a yearly 'rental' for the use of the machine. Leasing also enables working capital to be put to other uses and usually involves a 3–5 year term. A secondary consideration in individual ownership or leasing is the availability of a secure storage and the availability of local dealership and parts services. Most important however is having enough work on the farm or in the district to extend machine hours for an economically-viable harvest business operation.

Alternatively, if contracting is under consideration, it needs to be asked: is a contract operator or machine available on time, and is the custom operator available where needed and at a reasonable price?

TABLE 2 Advantages and disadvantages of ownership versus contracting

Individual ownership	Hiring a contractor
The machine is on the farm ready for harvest when needed.	No large capital outlay in the machine, but contractor may not be available when needed.
Local care and preventive maintenance reduces downtime.	No breakdown worries or bills.
Quality of harvest performance is under full control of the farmer.	No expertise needed to service or repair harvester.
Can be cheaper than a contractor if there is sufficient harvest work (or crop area).	No time expended in machine servicing or repairs.
Operational and service skills are required and the equipment should be stored adequately.	The farmer is free to do other tasks while contractor is working.
Finance has to be sought, loan has to be repaid; but this may have tax advantages.	Farmer is able to access the latest machinery.

Source: Kondinin Group.

Safe operation of harvesting equipment

- Never attempt to lubricate, clean, adjust, or unplug harvesters when the machine or engine is running.
- Read and understand the operator's manual.
- Gain a thorough understanding of the controls before operating machine.
- Operate controls only when in the operator's seat or from a designated operator's area.
- Keep all shields in place.
- Do not allow anyone to climb onto the machine while it is in motion.
- Keep children at a safe distance from harvesting equipment. Be sure no one is nearby when the machine is started.
- Do not operate the machine when tired.
- Keep a fire extinguisher at hand.
- When refuelling, stop the engine and do not smoke. Ensure that fuel system has no leaks.
- Do not run the engine in an enclosed building.
- When working around machinery, wear work clothes that fit snugly — loose clothing can get caught in moving components.

Useful units and measures

One hectare (ha) = 10,000 m^2 (100m by 100 m). 1ha = 2.471 acres.

One kilometre = 0.6214 miles.

One km/h = 0.6214 mph = 0.28 m/s. 1m/s = 3.6km/h. 100km/h = 62.14 mph = 27.8m/s.

Thresher tip speed for rice is 15–35m/s (54–126 km/h).

Calculate tip speed S (m/s) from S = 3.14 * Dia (m) * drum speed RPM/60.

Pressure 14.7 psi = 1 bar = one kilogram/cm^2(approx) = 100kPa. 1psi = 7kPa (approx). 1000 psi= 7mPa.

One kiloNewton = 100 kg = 220 lb.One kgf = 10N (approx).

One horsepower = 0.746Kw. One kW = 1.34HP.

Calculate power (Watts) = Force (N) * Speed (m/s).

Torque: 1 lb.ft = 1.356 N.m. One kgf.m = 9.807 N.m. One N.m = 0.74lb.ft.

Power (kw) = Torque (kN.m) * RPM* 0.1047 = Torque (N.m) * RPM/5500.

Some physical properties of rice

Bulk densities of paddy/rough rice varieties

Australian varieties:
Medium Grains = 650–675kg/m^3.
Long Grains = 580–600kg/m^3, about 46lb/Bu.
Imperial bushel = 1.03 US Bushels = 8 gallons = 1.281ft^3 = 36.4 litres.

(Compare with US paddy at 579 kg/m^3, that is 36lb/ft^3 or 45lb/Bu, 49Bu/tonne). One US Bushel (1.25ft3) = 45lb paddy (20.41 kg) = 35.2 litres.

{cf wheat: 772kg/m3 (60lb/Bu, 36.7 Bu/tonne)
(One Bushell = 1.25ft^3)}.

Rice husks:128kg/m^3 packed, 117kg/m^3 loosely packed (Wimberly 1983).

Rice trash: 160kg/m^3 packed, 65kg/m3 loose.

Specific gravity paddy
1.11SG @ 11.9% moisture with 50.4% air space

Specific heat paddy
@ 10–17% moisture: 1.11 KJ.kg.0k (ASAE D243.3).

Coefficient of friction

Rice on smooth steel	0.41
Rice on concrete	0.52
Rice on wood	0.44

Thousand grain weights for paddy

Long grain (3.5:1 L/W ratio)
Example Pelde 23g/1000 (cf. US 15–18g/1000 seeds).

Medium grain (2.2:1 L/W ratio)
Example Amaroo 27g/1000
Millin 26g/1000 (cf US 17–21).

Short grain (1.8:1 L/W ratio) (US 20–23g/1000).

Angle of repose, heaped rough rice: 25–35° (RCL)
(cf 36–37° Wimberly, 1983).

Equilibrium moisture content, rough rice:
In air at 25°C, 60% r.h. – 11.8% moisture (wb.)
90% r.h. – 17.6% moisture (wb.)
at 38°C, 60% r.h. – 10.3% moisture (wb.)

Straw moisture level at harvest: 50–70%, wet basis.

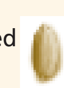
Paddy moisture level at harvest: 14–27%, wet basis.

Crop conditions for harvester capacity testing

	Rice	Wheat
Acceptable range of MOG/G	1.0–2.4	0.6–1.2
Range of Grain MC	15–28%	10–20%
Range of MOG	MC20–60%	6–25%
Acceptable processing loss	3%	1%

(ASAE/ ANSI Standard S 343.3) Comparing rice and wheat

MOG = Material other than grain. In their standards, ISO adds: ‘Harvester capacity is measured at maximum sustained MOG feed rate at stated processing loss level.’



Useful contacts and manufacturers

Ricegrowers' Association of Australia
Yanco Avenue
Leeton NSW 2705
Phone: (02) 6953 0433
Fax: (02) 6953 4733

Ricegrowers' Co-Operative Ltd.
Head Office
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Leeton NSW 2705
Phone: (02) 6953 0411
Fax: (02) 6953 4733

Grower Services
Phone: (02) 6953 0410
Fax: (02) 6953 7208

Deniliquin Office
Phone: (03) 5881 2740

Mill - Calrose Street Leeton
Phone: (02) 6953 0522

White Rice Mill
Phone: (02) 6953 0519

Appraisals Laboratory
Phone: (02) 6953 0549

Appraisals Field Staff
Phone: (02) 6953 0553

Coleambally Office and Mill
Phone: (02) 6954 4136

Deniliquin Office and Mill
Phone: (03) 5881 2477
(03) 5881 2221
(03) 5881 2509

Echuca Office and Mill
Phone: (03) 5482 1422

Griffith Office and Mill
Phone: (02) 6962 4088

Yenda Office and Mill
Phone: (02) 6968 1149

Weighbridges

Benerembah:	(02) 6963 4224
Blighty:	(03) 5882 6307
Burraboi:	(03) 5887 2202
Caldwell:	(03) 5884 2118
Coleambally:	(02) 6954 4182
Deniliquin:	(03) 5881 2499
Emery:	(02) 6954 6732
Finley:	(03) 5883 1760
Gogeldrie:	(02) 6955 9220
Griffith:	(02) 6962 1395
Hogan:	(03) 5885 6548
Leeton:	(02) 6953 0566
Moulamein:	(03) 5887 5200
Murrami:	(02) 6955 2218
Walsh (Eulo):	(02) 6954 4258
Warrawidgee:	(02) 6968 6211
Whitton:	(02) 6955 2727
Whitton Seed shed:	(02) 6955 2788
Widgelli:	(02) 6963 6550
Willibriggie:	(02) 6968 5263
Yenda:	(02) 6968 1071

Rice Marketing Board of NSW
Yanco Avenue
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Phone: (02) 6953 3200

The Co-operative Research Centre for Sustainable Rice Production (Rice CRC)
C/- Yanco Agricultural Institute
Private Mail Bag
Yanco NSW 2703
Phone: (02) 6951 2713
Fax: (02) 6955 7580

MACHINERY DEALERS

Codemo Machinery Services Pty Ltd (AGCO)
Phone: (02) 6962 6244
Fax: (02) 6962 5572

Coleambally Riverina Machinery (John Deere)
Phone: (02) 6954 4280
Fax: (02) 6954 4415

Combined Agricultural Machinery Pty Ltd (AGCO)
Phone: (03) 5881 1355
Fax: (03) 5881 4338

Corawa
Header World Pty Ltd
Phone: (02) 6033 1577
Fax: (02) 6033 3163

D & D Machinery
Phone: (02) 6962 1477
Fax: (02) 6962 7633

Deniliquin
Taskers Garage (New Holland)
Phone (03) 5881 2176
Fax: (03) 5881 4569

Deniliquin Machinery (White)
Phone: (03) 5881 3139

Finley
Armstrongs Finley Sales & Service (John Deere - Shelbourne)
Phone: (03) 5883 1655
Fax: (03) 5883 2095

Finley AG (Case)
Phone: (03) 5883 1966
Fax: (03) 5883 1689

Gough & Gilmour (Caterpillar)
Phone: (02) 6962 4890
Wagga: (02) 6921 7376
Fax: (02) 6921 1234

Griffith
A & G Machinery Pty Ltd (John Deere)
Phone: (02) 6962 1422
Fax: (02) 6962 3497

Hay
CM & IM Thompson (New Holland)
Phone: (02) 6993 1661
Fax: (02) 6993 3201

JS Vagg & Co (New Holland)
Phone: (02) 6962 1022
Fax: (02) 6962 6378

Leeton
Logan Bros Sales Pty Ltd (Case)
Phone: (02) 6953 3388
Fax: (02) 6953 3609

MIDF Co-operative Society (New Holland)
Phone: (02) 6953 2977
Fax: (02) 6953 4598

Murdock & Gaffey (Case)
Phone: (02) 6962 4411
Fax: (02) 6962 7671

Narrandera
Riverina Machinery Pty Ltd (John Deere)
Phone: (02) 6959 1522
Fax: (02) 6959 3140

MANUFACTURER HEAD OFFICES

AGCO Australia Limited
Phone: (03) 9313 0313
Fax: (03) 9311 8171

Case Corporation Pty Ltd
Phone: (02) 9673 7777
Fax: (02) 9833 1341

Caterpillar of Australia Ltd.
Phone: (03) 9339 9333
Fax: (03) 9335 3366

John Deere Ltd
Phone: (07) 3802 3222
Fax: (07) 3803 6555

New Holland Australia
Phone: (02) 9627 5611
Fax: (02) 9627 5922

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Agspares Pty Ltd
Deniliquin
Phone: (03) 5881 1255

Spiral Reconditioners
Phone: (03) 5881 1240

HARVESTER FRONTS

Harvest Hustler
Swan Hill T&I Centre
(also a Case dealer)
Phone: (03) 5032 4555
Fax: (03) 5032 2309

Harvestaire Pty Ltd
Phone: (08) 9344 7433
Fax: (08) 9345 3256
(componentry sold through the Neils Parts group)

Honey Bee
Muddy River Trading Company
Phone: 041 860 7266
Fax: (02) 6792 6048
(also through New Holland dealers)

MacDon Australia
Phone: (03) 9432 9982
Fax: (03) 9432 9972

Primary Sales Australia
Head Office
Phone: (08) 9250 3500
Fax: (08) 9250 3600
Eastern Office
Phone: (02) 6882 2844
Fax: (02) 6884 0424
(also agents for Vibra-Mat)

Shelbourne Reynolds Australia
(also Armstrong Machinery - Finley)
Phone: (03) 9360 4899
Fax: (03) 9360 4955

HARVESTER SPARE PARTS

Agricultural Implement Spares (A.I.S.)
(Nichols Concaves dealers)
Phone: 1800-656611

Agricultural Rubber and Plastics (ARP)
Phone: (08) 8340 0195
Fax: (08) 8340 0849

Collier & Miller
Phone: (02) 6964 3711
Fax: (02) 6964 1908

Condingup Wreckers
Phone: (08) 9071 3389
Fax: (08) 9071 4109

Header World
Phone: 1800-029894
Fax: (02) 6033 3163

Nichols Concaves
Phone: (08) 9353 3244
Fax: (08) 9353 3939

Niels Parts
Corowa
Phone: 1800-246991
Phone: (02) 6033 160
Fax: (02) 6033 2835

Tractor Wreckers of Kulin
Western Australia
Phone: 1800 807 036
Fax: (08) 9880 1352

RICE CONTRACTORS

Australian Grain Harvesters Association
Administration
Phone: (02) 6761 2244
Fax: (02) 6766 7330
Hotline: 015 127 687

CHASER BIN MANUFACTURERS

Bordignon Engineering
Phone: (02) 6964 3777

Cleverdons Steel
Phone: (02) 6977 2811

Turner Engineering
Phone: (03) 5881 1803
Fax: (03) 5881 3838

AGRONOMISTS – NSW AGRICULTURE

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Fax: (03) 5881 3719

Warwick Clampett
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Fax: (02) 6963 0255

Rachael Salvestro
District Agronomist, Griffith
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Fax: (02) 6963 0255

Andrew Schipp
District Agronomist, Hay
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Fax: (02) 6993 2177

Wendy Sutherland
District Agronomist, Deniliquin
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Fax: (03) 5881 3719

Yanco Agricultural Institute
Switchboard
Phone: (02) 6951 2611
Fax: (02) 6955 7580