Alternative Uses for Australian Rice Straw

This publication is designed to assist Australian ricegrowers and advisors to consider novel solutions for the management of rice straw by compiling case studies and research undertaken within the industry into a user-friendly guide.

It provides descriptions, photographs and basic economic information about rice straw management options, with references to sources of more detailed information.

Acknowledgements

This publication was produced by the Moulamein Cropping Group in conjunction with Rice Extension, using information provided by the Ricegrower's Association of Australia Environmental Champions Program and various industry members, as part of the Australian Government's National Landcare Program.

The authors would like to acknowledge the invaluable information provided by the rice growers and industry members who feature in the case studies below. Their collaboration has been essential for this project and enables us to provide an open and realistic review of novel methods for managing rice straw.

A special thanks to Mr Neil Bull for sharing his draft: Alternative Uses of Rice Straw, from which almost all of the case studies contained within this publication are derived.

Compiled By

Laura Kaylock, Western Murray Land Improvement Group Inc., Barham; Troy Mauger and Charleton Glenn, Rice Extension, Deniliquin; and Neil Bull, Ricegrower's Association of Australia, Deniliquin, NSW.

Published By

Douthat Design & Print, Kerang VIC.

Disclaimer

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The Impacts of Stubble Burning

This guide has been produced as part of a larger project funded by the Australian Government's National Landcare Program, aiming to investigate alternative management options for rice stubble post-harvest in NSW. The project was initiated by the Moulamein Cropping Group (MCG) in response to concerns over the sustainability of stubble management within rice systems in Australia.

Rice crops can leave stubble loads of up to 15 tonnes if a 12 tonne per hectare crop is grown. This poses a significant issue for farmers due to blockages and poor seed-soil contact when sowing a consecutive crop. To cope with this constraint, often stubble is burnt 1-6 months after harvest to improve trafficability and establishment of the following crop. This poses both an environmental and economic disadvantage, as studies suggest that burning reduces nutrient levels and releases carbon dioxide, monoxide and nitrous oxide which can increase the likelihood of human respiratory problems and contribute to greenhouse gases.

Clouds of smoke from straw burning often gets trapped in inversion layers in typical Riverina autumn weather conditions and it is possible that an introduction of government regulatory control on burning may occur if there are reports of smoke affecting individuals or local communities to the NSW Environment Protection Authority (Quayle, 2016).

Greenhouse gas emissions are also a concern as the carbon content of rice straw is about 40% and in an average rice growing year 800,000 tons of straw is burnt in Australia. That equates to 320,000 tonnes of carbon released into the atmosphere (Vagg, 2013). It should be noted that the incorporation of rice straw actually has more potential to contribute to greenhouse gasses than burning. This is due to the production of methane, which has 20-25 times the heat capturing potential of a carbon dioxide molecule. When rice straw is added to the soil methane emissions can increase 3-12 times (Bainbridge, 1997), with extended periods of ponded water generating the highest emissions. Considering this, options like Biochar or the creation of bio-composite (building) materials may be preferential for the industry, as their emissions are far lower.

Research has shown that repeat burning of stubble can diminish soil bacterial populations by more than 50% (Biederbeck et al., 1979), whereas retaining plant residues improved soil structure by increasing soil microbial processes (Ugalde et al., 2007). Economically, high levels of nutrients retained in stubble are lost via burning. In some cases, up to 100kg/ha of Urea could be needed to replace the nitrogen lost (Norton, 2017). This is a significant cost to farmers. Hence, the retention of stubble has the potential to improve long-term fertility. For example, research in Yanco NSW it was found that there was 22% more nitrogen uptake by rice in plots where stubble was successively incorporated (Kirkby, 2000).

The aim of this guide is share information about the experiences of others who have trialled alternative stubble management practices in their business or through their research, with the aim of increasing producer knowledge in this area. We hope that the information contained in this publication will increase the adoption of some of these practices or lead to further experimentation with novel solutions for managing rice stubble in Australia.

Incorporating Rice Straw

ADVANTAGES:	Build organic matter, improve soil health, increase soil water holding capacity, alternate source of stockfeed
DISADVANTAGES:	Delay planting of following crop, increased cost of machinery operations, trafficability at seeding due to remaining wheel ruts, fertiliser nutrient tie-up

Burning rice stubble not only removes the crop residue, but also the nutrients contained within it. If we assume that a 12 t/ha rice crop contains 63kg/ha of N in stubble, this is worth 137kg/ha of Urea. Based on a price of $500/tonne for Urea, $68.50/ha of N would be lost from the system. For phosphorus, the loss is shown to be 5kg/ha. Assuming this was replaced by MAP at a rate of 22kg/ha, the cost of this would be $15.50/ha. Combined, this nutrient loss potentially costs farmers up to $84.00/ha. Even if only half of the nutrients contained in the stubble are retained, the savings from this would be in the range of $42.00/ha.

The advantages of retaining stubble in the soil compared with burning include improved soil health, a feed source for animals and a source of nutrients over a prolonged period. The main disadvantages are the time potentially spent out of rotation and the uneven seedbed for crops sown into stubble.

Examples of incorporating rice straw include:

- **Using a Mouldboard Plough**
- **Using an Offset Disk Plough**
- **Retaining Stubble on the Surface**
- **Establishing Legumes in Rice Stubble**
- **Feeding Lambs on Rice Stubble**
- **Sowing into Rice Stubble**

Quick Facts:

Grower: Harry Kooloos
Region: Eastern Murray Valley
Stubble Management: Incorporation
Next Crop: 12 months
Notes: nutrient savings & moisture retention outweigh time lag for sowing winter crops
Total Profit ($/ha): –$144.39 - $34.25

Using a Mouldboard Plough

Harry Kooloos, a farmer from Mayrung, has been trialling different incorporation methods to manage his rice stubble for many years in.

For many years following rice harvest in April, Harry would incorporate his stubble using a mouldboard plough prior to December to a depth of 10-12cm. The mouldboard plough is able to turn and bury the stubble in one pass; however, it is a slow process and requires moisture at the time of ploughing. In good conditions, Harry could plough 1 ha/hr with an 80HP tractor pulling a 4-shank plough. The incorporation would then be followed by two passes with an offset disc plough over the summer and then a grader board prior to sowing to complete the seedbed preparation.

More recently, Harry has been using a 4.5m heavy offset disc plough with a ridge roller hitched behind it to improve his efficiency when incorporating rice stubble. The plough has been modified to have 8" spacings between front discs and 10" spacings on back discs, enabling stubble to be chopped up by the front row and soil to be turned over by the back row. The discs do not follow in the same tracks, leaving the ground flat. This method needed a 150HP tractor and covered 3.4 - 4 ha/hr, depending on layouts.

After two passes with this combination, the seedbed is suitable for sowing a winter crop. Harry believes this quick turnaround is possible due to the extensive root system rice plants develop from the delayed permanent water system. This allows for the roots to be chopped up by the plough, rather than being turned over as a ball of roots, which is the case with aerially sown crops. He also attributes the speedy breakdown with the improved soil contact from the ridge roller following the plough. The ridges have the added benefit of holding the rainfall in the soil during periods of heavy rainfall during the summer.

The Economics:

Mouldboard Plough	$90.00	Plough & Roller	$50.00
Offset Disc Plough	$70.14		
Nutrient Savings	+$42.00	Nutrient Savings	+$42.00
Total Profit ($/ha)	-$144.39		-$34.25

Photos: Harry's offset disc plough in action, with a ridge roller hooked on behind and the end result after two passes, Deniliquin NSW.

Using an Offset Disc Plough

Quick Facts:

Grower: Michael Chalmers
Region: Western Murray Valley
Stubble Management: Incorporation
Next Crop: 6 - 12 months
Notes: 93mm of summer rain may have sped up stubble decomposition
Total Profit ($/ha): An offset disc plough ($53.71/ha) provided a comparable seedbed to burning stubble ($68.82/ha)

Michael Chalmers runs a mixed enterprise in Noorong, with a focus on irrigated cropping. Michael had concerns about the long-term sustainability of burning rice stubble, and wanted to revisit the concept of incorporating stubble to see whether it could be a viable option for his business.

In November 2017 he participated in a rice stubble incorporation demonstration with the Moulamein Cropping Group. Treatments included the use of a Grizzly Tiny offset disk plough, a K-line Speed Till, a Muthing Stubble Mulcher and a Ridge Roller compared with the control (burning).

Although burning remained the cheapest option, incorporation with an offset disc plough resulted in a comparable seedbed. One pass using the Grizzly Tiny plough to a depth of 10cm in November and again in January using a 12m Field Boss plough to level the surface, was enough to prepare the paddock for sowing. A grader board was also used in April to create a friable surface for plant establishment.

Mulching prior to incorporation or rolling afterwards did not speed up the breakdown of stubble or improve soil friability at sowing. However, it did make the incorporation of stubble much easier, requiring less horsepower from machinery and provided an even spread of stubble. The speed till struggled to cut through the 10 t DM/ha stubble, even after one pass of the offset disc plough.

Please Note: Decomposition rate of stubble breakdown may have been elevated due to higher than average summer rainfall events (92.6mm during 5 months that treatments were applied).

The Economics:

	Control	Plough	Mulch + Plough
Burning Stubble	$7.50		
Mulching Stubble (Contractor)			$75.94
Grader Board	$26.25	$26.25	$26.25
Offset Disc Plough	$35.07	$69.45	$69.45
Nutrient Savings		$42.00	$42.00
Total Profit ($/ha)	-$68.82	-$53.71	**-$129.66**

Photo: The Grizzly Tiny Offset Disc Plough and first pass of the rice stubble at Michael Chalmers' property, Noorong NSW.

Quick Facts:

Grower: Andrew Hicks
Region: Western Murray Valley
Stubble Management: Retained on surface
Next Crop: 12 months
Notes: Stubble management benefits the whole system by reducing overall crop water use
Total Profit ($/ha): –$61.32

Retaining Stubble on the Surface

The Hicks family from Pretty Pine have been mulching rice stubble for a number of years. They believe that this practice improves the moisture holding capacity of their soils and increases the productivity of their farming system.

Rice is the main crop grown on Andrew Hicks' property, "Wandarra", with cereals only grown after a full profile of moisture.

In 2014 rice stubble was mulched at directly after harvest and then left to sit on the soil surface. Mulching was completed using a 300HP John Deere tractor which used around 30L/hr of fuel (covering 2.5ha/hr).

In early February 2015, this paddock had a full profile of moisture, whereas other paddocks on the farm were dry. It was observed that the stubble had already broken down considerably and the soil was soft enough to dig a shovel into it (as per pictures below). One of the problems associated with this method is that areas where wheel tracks remained became extremely hard and cloddy. Hence the paddock was subsequently levelled out using an offset disc, followed with a grader board to improve tilth prior to sowing a winter crop.

Andrew believes that even when cereal crops aren't grown using the residual moisture from the rice, their stubble management benefits the farming system, as it reduces their overall rice crop water use.

The Economics:

Mulching (Farm)	$42.00
Offset Disc Plough	$35.07
Grader Board	$26.25
Nutrient Savings	+$42.00
Total Profit ($/ha)	-$61.32

Photo: Steve McGrath's mulcher at work in rice stubble.

Photo: Rice stubble immediately after mulching in 2013 and resulting breakdown of stubble in 2015.

Establishing Legumes in Rice Stubble

Quick Facts:

Region: All
Stubble Management: Retained on surface
Next Crop: <1 month
Notes: Balansa & Persian clovers produces 1.4 – 2.5t DM/ha in 2016 which could return up to 46-80kg n/ha to the system
Total Profit ($/ha): $41.00

Recent work by Malcom Taylor and the Rice Extension team showed remarkable establishment of legumes sown into rice stubble after harvest.

Common legumes including Sub clover, Balansa clover, Persian clover, Arrowleaf clover and Common vetch were trialled during 2015 and 2016 on farms in the Murrumbidgee and Murray Valley Irrigation Areas.

In 2016 all sites suffered waterlogging, with the best establishment occurring in cut or rolled stubble. Germination and growth of legumes was best where stubbles were mulched or where wide spacings were used to plant the preceding rice crop.

Balansa and Persian clovers were most productive in 2016, with 1.4 – 2.5t/ha DM produced. Research from the Rice CRC Research Report and the CSIRO suggest that the portion of N fixed by mixed pastures with a largely legume component could be expected to return 25-32kg N/t DM. Using the above production as an example, this equates to: 45 – 80kg N/ha of nitrogen returned to the system.

If you are only looking for a single season of production, soft seeded Persian clover is a good option, if you want a long-term pasture then planting a Sub clover or Balansa clover will readily establish over numerous seasons. Using a mix of clovers can provide the highest level of ongoing production.

It is recommended that sowing rates of 10kg/ha for Trikala, 5kg/ha for Balansa & Persian clover are used. The seed should be coat seed in a Group C inoculant. However, it is not recommended to spread fertiliser with the seed as this may kill the inoculated rhizobia.

Risks:

- Waterlogging - wet winters only occurred in 22% of years with this dropping to 12% between 1966-2016. Legumes best suited to waterlogging are: Trikkala sub clover, Shaftal (Persian) clover or Balansa clover.
- It is advised that you don't establish clovers in rice stubble and then re-sow the paddock to rice in the same year due to the increased risk of stem rot carryover.
- Poor germination from a lack of light and space in rice stubble may limit germination. Harvest at a lower height and spread trash evenly over stubble or rolling or mulching stubble.

The Economics:

Aerial Spreading	$25.00
Seed (eg: Balansa)	$25.00
Nutrient Savings	+$91.00
Total Profit ($/ha)	$41.00

Photo: Clover sown into rice stubble in 2015 regenerated with one additional watering, pictured September 2016.

Quick Facts:

Grower: Graeme & Verneice Dick
Region: Western Murray Valley
Stubble Management: Retained on surface
Next Crop: <1 month
Notes: Keep sowing rates up but avoid buying expensive seed due to risk of failure.
Total Profit ($/ha): $31.00

Feeding Lambs on Rice Stubble

Graeme and Verneice Dick at Bunaloo integrate first cross lamb production with their rice system by sowing grazing legumes after a rice crop. From this system, they regularly get 2-3 grazing's from the paddock by the end of spring.

Graeme firmly believes that retaining stubble for ground cover is key to long-term productivity on his farm. This belief has led him to trial his own seeding system for legumes in rice stubble to feed his first cross lamb operation.

The legume pasture containing a mix of Balansa clover sown at 10kg/ha and Shaftal clover at 5kg/ha is sown as soon as the ground is trafficable after rice harvest. In 2019 the Dick's were able to feed 200 weathers for four months on the 40ha legume pasture. No irrigation was applied to this pasture.

The pasture was sown into tall, standing stubble using a 4m Agrifarm aerator with a mounted seed box on a 160HP tractor. Two passes were completed with this machine to achieve even seed application and better establishment. Graeme is currently building his own prototype rotary drum seeder to be mounted on tractor linkage for extra height and to minimise wheel tracks on soft ground.

Note: The Dick's have also been trialling native pasture options such as Kangaroo grass to replace the legume pasture. The grass was sown in late 2018 with encouraging initial results, however a lack of moisture in 2019 has meant the grass was unable to set seed and is now dormant.

The Economics:

Sowing	$15.00
Seed	$45.00
Nutrient Savings	+$91.00
Total Profit ($/ha)	$31.00

Photo: Graeme gives some perspective on their legume pasture growth in 2016, Bunnaloo NSW.

Sowing into Rice Stubble

Quick Facts:

Region: All
Stubble Management: Retained on surface
Next Crop: <1 month
Notes: This technology is still within its trial phase
Total Profit ($/ha): $27.50-$34.40

Innovative technology by the SA NoTill Farmers Association to cut though high stubble loads may assist with direct seeding following rice. The AquaTill liquid coulters use an ultra-high-pressure (UHP) waterjet to slice through residue and the system has the potential to completely transform seeding operations.

The technology compresses liquid to 50,000 psi and feeds it through a small nozzle 0.25mm in diameter, resulting in a powerful cutting stream traveling nearly three times the speed of sound.

independent trials at the Agriculture Machinery Research and Design Centre suggests that a nominal 150L/ha volume of water could sustain straw cutting capacities of up to 12.5t/ha, 19 t/ha and 35t/ha at 300mm, 500mm and 1000mm row spacing respectively (Desbiolles, 2019).

This system also has the ability to apply selected liquid fertiliser, herbicides or insecticides through the coulter jets to reduce the number of passes required post-drilling.

The Economics:

Row Spacing	381mm (15")	762mm (30")	1016mm (40")
Liquid Rate (L/ha)	288L	149L	115L
Operating Cost* ($/ha)	$14.50	$9.10	$7.60
Nutrient Savings ($/ha)	+$42.00	+$42.00	+$42.00
Total Profit ($/ha)	$27.50	$32.90	$34.40

* Estimate only and assumptions include:
1) 10 km/hr groundspeed.
2) 010 orifice at 50,000 psi.
3) Includes Flow UHP pump servicing and nozzle replacement per operating schedule.
4) Diesel consumption at $0.90 per litre after rebate.
5) Does NOT include tractor or stationary engine servicing.
6) Does NOT include cost for liquid (water or a mix of water with UAN).
7) Does not include capital cost for equipment that is still in development.

Photos: (left) The UHP waterjets in action, (middle) the liquid coulters slice open stubble ahead of a seeding disk, (right) the incision left by the liquid coulters.

For More Information: Greg Butler, Research & Development Manager of the South Australian NoTill Farmers Association greg@santfa.com.au or 0427 424 278. **Modelling for this article is provided by SANTFA with support from the National Landcare Program.**

Rice Straw Removal

ADVANTAGES:	Minimal delay in new crop planting and an alternative source of income
DISADVANTAGES:	Loss of nutrients, soil compaction, high associated costs and limited market size

Removing stubble from the paddock by cutting and baling enables the end product to be used for a range of uses, leaving the rice field ready for sowing subsequent crops. Current uses of rice straw include: garden mulch, building construction, sediment control, pollution management, composting, fodder and bedding.

The main advantages of removing rice straw from the paddock in comparison with burning are an alternate source of income and protection of soil microbes from damage during burning. The disadvantages are increased soil compaction, high costs involved and limited market size.

Examples of removing rice straw include:

- Using Rice Straw as Fodder
- Using Rice Straw Garden Mulch
- Composting Rice Straw

Rice Straw as Fodder

Quick Facts:

Growers: Nathan Pate & Ashley Dempster
Region: Eastern Murray Valley
Stubble Management: Removed from paddock
Next Crop: <1 month
Notes: Maintain livestock with rice straw + supplementation
Total Profit ($/ha): $149.07

Tocumwal rice farmer Nathan Pate participated in a feed test using his Sherpa stubble, with the aim of improving rice straw or silage protein and digestibility.

In this trial, stubble was cut at 15cm high, immediately following harvest with a self-propelled mower conditioner with tri-lobe super conditioning rollers. Stubble was baled and wrapped using a 6'x4'x3' Massey Ferguson square baler.

The application of 9kg of Urea granules directly on to stubble rows immediately prior to baling and wrapping, increased crude protein from 3.2% DM to 10% DM and metabolizable energy (ME) of silage from 5.2 to 5.9 MJ/kg DM. (Bull & Marshall, 2013). As a result, the protein content of rice straw silage fell into a similar range as that of cereal or pasture hay but the ME remained below the accepted range for hay or silage.

Another method of increasing the feed quality of rice straw is to inject wrapped bales or a sealed stack of square bales with Anhydrous Ammonia gas using spear or probe. In 2004 a study comparing the quality of rice hay, silage and straw the anhydrous ammonia treatment increased protein by 6.6% and ME by 1.5%.

Table 1. Feed quality results of rice straw and silage (NSW Agriculture, Rice Straw Tech Notes 2004, R Whitworth)

	Rice straw - dry	Rice straw silage (Amaroo) untreated	Rice straw silage (Amaroo) treated with ammonia gas
Protein	3.0%	3.1%	9.7%
Digestibility	43.0%	46.6%	55.2%
Energy (Mj/kg DM)	5.5%	5.9%	7.4%
Moisture	<10.0%	62.2%	50.6%

Existing research suggests that treating rice straw with nitrogen can typically increase protein by 5-6% and digestibility by 2-10% (Whitworth, 2003). Applying Urea at rates of 4% or anhydrous ammonia at 3% of the dry matter weight of the bale is required to achieve these results and baling or wrapping should occur within 24 hours of harvest.

In 2004 dairy farmer, Ashley Dempster processed 5,000 bales of rice straw using his fixed chamber baler in the Coleambally area. To improve the feed quality of these bales, he gassed them using anhydrous ammonia. In 2019 Ashley baled 8,000 bales of rice straw and notes that baling immediately after harvest delivers the best results. He believes rice straw can be a valuable feed source to maintain cattle in times of drought, if supplemented appropriately.

Note: Always obtain nutritional advice before feeding rice straw-silage to livestock.

The Economics:

Baling & Wrapping	$490.00
Urea	$95.93
Transport-pickup & stack	$35.00
Value of Rice Straw	+$770.00
Total Profit ($/ha)	$149.07

Photo: Fixed chamber baler and silage wrapper being used immediately after rice harvest

Quick Facts:

Grower: Glen Collis

Region: Murrumbidgee Irrigation Area

Stubble Management: Removed From Paddock

Next Crop: <1 month

Notes: Bale straw as soon as possible to maintain quality

Total Profit ($/ha): $238.00

Rice Straw Garden Mulch

Utilising the local market has been key to the success for Griffith farmer, Glen Collis. After seeing the potential of rice straw to provide a weed & chemical free, slow-rotting mulch for gardens; he started looking for ways to introduce the product to the market.

To begin with, the Collis family installed a garden mulch packing facility to process rice straw into 10kg bags for retail through the hardware-garden supply outlet, Brunnings. Unfortunately, this market is quite competitive, making it difficult to achieve reasonable prices against well-known products such as 'sugar cane mulch'. Having a middle man in the process made the margins even more slim.

As a result, Glen decided to target the local market with small or large rectangular bales instead. Baling quantities for this market are based on the amount of straw available from their own crop and select neighbours. He currently has demand to product between 2000-5000 big squares and 5000 small squares. This demand tends to be seasonal, peaking in autumn, spring and school holidays. In addition, Glen is also developing a market on the south coast for the garden mulch. Demand for this is currently 6 B-double loads per year.

The excess bales of straw are used to provide fibre for the Collis' stock and marketed as stockfeed to other farmers during times of drought.

When baling, the straw must be clean with good colour. Weeds and dead animals will not be tolerated by clients. For best results, Glen harvests at 20% moisture then mulches straight afterwards to shred the product for better drying. He also finds that the mulchers handle rice straw far better than mower conditioners, which tend to be worn out by the abrasive nature of the straw. The straw is then raked using a rotary hay rake roughly 5-6 days after mulching and baled the next day. Ideally the bales are then stored in sheds to protect them from the weather and maintain colour.

The Economics:

Mulching	$42.00
Baling & Raking	$490.00
Transport	$70.00
Value of Rice Straw	+$840.00
Total Profit ($/ha)	$238.00

Photos: (left) Rice straw is raked 5-6 days after mulching and baled the next day.

Composting Rice Straw

Ross O'Halloran (Waterhold Pty Ltd) trialled rice straw as a novel ingredient for compost on potato grower, John Tippet's Tooleybuc farm in NSW.

Quick Facts:

Manager: Ross O'Halloran

Region: Tooleybuc

Stubble Management: Removed from paddock

Notes: Monitor compost closely to prevent going anaerobic

Total Profit ($/ha): –$604.50

Whilst the rice straw was a novel compost ingredient, it did not differ greatly from other types of material used to make compost. However, it did require particular attention whilst being made. The compost needed to be monitored closely to ensure it remained aerobic throughout the entire process.

To prevent compost from becoming anaerobic, the C:N ratio of all ingredients must be considered. High carbon products should make up 45% of the batch, followed by green waste at 30% and manures at 25%. Avoid a high ratio of fine materials in the mix, as this will limit airspace and time the turning of compost based on temperature, smell and colour.

The starting material of the rice compost was: straw, hulls, pig manure, orange pulp, pistachio hull waste, red gum saw dust and compost teas.

There was no extra cost incurred to compost rice straw as compared with barley straw. The first 2 turns if the rice compost were slower than the barley, however this was compensated by faster turns of the rice compost later in the process.

Ross believed that the rice stubble compost showed a greater diversity of biological species than barley but lacked behind the barley in nutrient analysis. In his experience the diversity was often more valuable than a nutrient analysis for overall productivity of the amendment. Growers usually maintain their existing fertiliser program in addition to the application of compost to meet nutrient requirements. Many report seeing a 20% increase in yield, as well as an improvement in overall crop resilience after multiple years of compost application, regardless of the nutrient composition.

In this trial, the cost of rice compost was in the vicinity of $87/t. However, if you have the rice stubble on hand and other inputs close by, then costs would be far lower. Composting usually costs between $35-45/t. Spreading rates of compost can vary from 2.5t/ha to 7t/ha with costs of $150/hr. For example: if you were to spread 7t/ha of compost at 4ha/hr, it would cost $37.50/ha.

This estimated cost is far higher than would usually be incurred due to the freight component. Ingredients used were representative of what rice growers would have access to in their regions, despite the distance of these from the composting site at Balranald.

The Economics:

Composting Materials	$609.00*
Composting	$20.00
Spreading	$37.50
Nutrient Savings	>+$42.00
Total Profit ($/ha)	-$604.50

For More Information: Ross O'Halloran, Managing Director of Waterhold Pty Ltd waterhold@bigpond.com or 0427 220 978

Photos: (left to right) The rice composting process from first turn through to the finished product.

Converting Rice Straw

✓ ADVANTAGES:	Potential to store or sequester carbon, new product & marketing opportunities
✗ DISADVANTAGES:	More research is needed, markets not developed & can be cost prohibitive

Biological fibres can be used to make value-added materials that are environmentally friendly and strong. Raw straw fibres and stems are resistant to decomposition as a result of their high silica content and have a relatively high coefficient of friction (Alternative Uses of Rice-straw in California, 1997).

The use of rice straw to create materials that would store or sequester carbon would decrease emissions and reduce global warming risks. It also adds a monetary return for what would usually be classified as a waste product.

Rather than burning rice straw resulting in lost nutrients and microbial diversity, converting rice straw for other uses provides an improved value for a by-product material, increased marketing opportunities and the potential to store carbon. The disadvantages to converting rice straw into other forms includes the high cost and developing markets associated with these options.

Examples of converting rice straw include:

- Creating On-farm Biogas
- Converting Stubble to Biochar
- Creating Straw Based Particle Boards
- Using Rice Straw to Create Straw Bale Homes

Photos: https://www.smallfarms.net/building-a-high-energy-efficiency-home-with-straw-bale/

On-farm Rice Straw Biogas

Quick Facts:

Grower: Ian Blight
Region: Murrumbidgee Irrigation Area
Stubble Management: Removed from paddock
Next Crop: <1 month
Notes: Densification technology is not yet economically feasible

Willbriggie farmer, Ian Blight, has been trialling on-farm biogas for 15 years to manage his rice straw and fuel costs.

Although Ian has not been able to run a commercially viable biogas system to power his diesel pumps yet, he believes the final frontier is to create an economical straw densification machine.

To produce Biogas, feedstuff such as straw briquettes or pellets are added into an airtight biomass gasification plant, which then incinerates the material in a controlled manner due to limited air supply to the fire. The burning process creates a by-product called 'syngas' which is a mixture of carbon monoxide, carbon dioxide and hydrogen gasses.

The syngas is then filtered in a 'scrubber' to remove particulate matter such as soot, and cooled through a radiator before being fed directly into the air intake of diesel pumps. This process can substantially reduce diesel use and pumps do not need to be altered to run on biogas. The production of Biogas is automated using programmable logic controllers to manage the addition of air and straw and maintain a stable air: gas ratio for burning.

To make the use of biogas economically viable, the cost of production must be less than the cost of diesel. The main constraint is the densification process required for controlled burning of straw in a gasifier. A straw bale only has density of 130 kg/m, whereas a briquette or pellet will average between 600 -700 kg/m. This means that if added to the gasifier, it would incinerate rapidly, leaving little gas behind to harvest. The slower burning of densified material results in a much higher syngas yield.

Ian suggests that a throughput of 20 t/hr of straw is necessary to economically produce briquettes in a densification machine, which essentially acts like a baler. Currently the only machine which is able to collect and densify straw in the paddock is the Krone Premos 5000 mobile pellet harvester, which has a throughput of 5 t/hr in cereal straw. The machine uses a 2.35 meter camless pick-up to gather the straw, while an 800mm wide rotor feeds the material to the feeding belt. A dispenser meters water or oil onto a bank of jets which spray the liquid on the matrix rollers. The material is then passed through matrix rollers which are heated to 70-100 degrees under high pressure during pelleting (O'Keeffe, 2020).

There may be other value-adding opportunities for densified pellets as an addition to livestock rations or bedding due to their absorption qualities. The downside of producing densified pellets is a higher risk of damage during unloading and cannot be stored for long as they tend to swell and lose shape (Quayle, 2016).

Due to the current experimental nature of this process, we cannot provide accurate economics for the production of biogas. The current feeling is that the densification process must cost similar to baling and the value of the biogas must be similar to the cost of diesel for the process to be economically feasible.

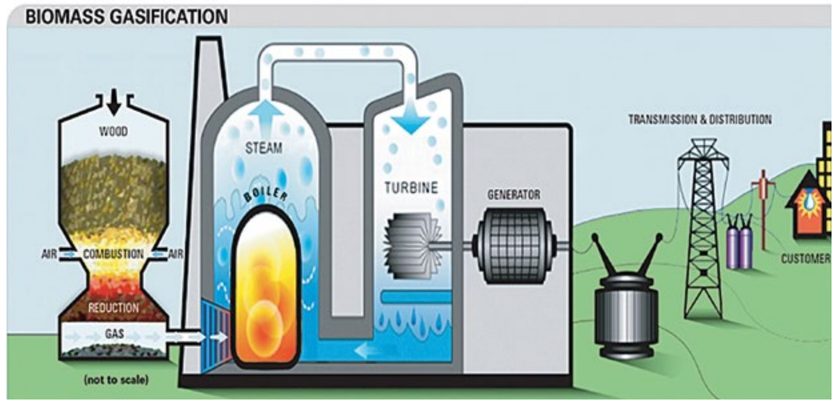

Image: A diagram showing the biogas gasification process.

Quick Facts:

Manager: Rice Research Australia Pty Ltd
Region: Eastern Murray Valley
Stubble Management: Removed from paddock
Next Crop: <1 month
Notes: After 3 years soil carbon increased

Converting Stubble to Biochar

Biochar is a solid, carbon-rich material produced when organic matter is heated in a low oxygen environment using a process called pyrolysis. The resulting product is stable for long periods (more than 100 years), providing potential to sequester carbon in soils.

The benefits observed from the application of biochar include: enhanced nitrogen fixation, pathogen suppression, improved soil characteristics and decreased nitrate leaching. (Quayle, 2016). Studies have also shown that biochar can also decrease nitrous oxide and methane emissions from the soil.

The rice industry trialled the use of rice straw as a feed stock for biochar in three consecutive seasons starting in 2013. Rice straw was baled into 8'x4'x3' square bales and fed into the pyrolysis machine whole. The resulting biochar was then transferred into one tonne bags and spread using a manure spreader to uniforming distribute the product.

The trials found that after three seasons of biochar addition, total soil carbon increased significantly compared with the stubble removed plots. It was noted that in 2015-16 yields were higher for the biochar treatments compared with incorporation, removal and composting of stubble (Bull & Rose, 2018).

One option for obtaining a commercial pyrolysis plant is through a company called 'Pyrotech Energy', which is based in Melbourne and markets mobile pyrolysis plants capable of converting agricultural residues to biochar, bio-crude oil, syngas and wood vinegar.

The pyroflash plant is able to provide all of the above products as a result of the pyrolysis process and is best suited to mills or a cooperative where they can utilise the syngas and bio-crude oil to create energy and the biochar and wood vinegar to assist in organic farming practices. There are also opportunities to sell the by-products back to Pyrotech Energy to be further refined and sold into an international market. For farmers, the pyrogasification plant may be better suited to their systems, producing only syngas and biochar from agricultural residues. These plants are capable of producing 1.5 tonnes/day of biochar and a syngas energy of 33MWh/day.

The fully automated mobile pyrolysis plants are designed in a 40ft container allowing for transport according to demand. The system is capable of consuming up to 10 tonnes/day of feedstock. The rice straw will need to be pelletised first before entering the reactor with a 22% moisture content and <15mm diameter.

Due to the current experimental nature of this process, we cannot provide accurate economics for the production of biochar.

For more information: Christos Karantonis, Managing Director of Pyrotech Energy Pty Ltd christos.k@pyrotechenergy.com or 1300 714 305

Pyrotech Energy

Photo: The mobile pyrogasification plant

Straw-based Particle Boards

Biocomposites are a special class of materials combining natural fibres and natural resins. Straw can be compressed and heated to 280°C in a press to make a strong building panel without additives or adhesives.

Quick Facts:

Grower: John Gorman
Region: Collambally Irrigation Area
Stubble Management: Removed from paddock
Next Crop: <1 month
Notes: MDF alternative building panel
Total Profit ($/ha): $6,799.66

In Australia, Coleambally farmer John Gorman, has come up with an innovative biocomposite panel-board called AMPAN which is made primarily from rice straw. This product is used as a Medium Density Fibreboard (MDF) alternative building panel. The MDF particle board market in Australia uses approximately 550,000 cubic meters per annum, while the Coleambally Irrigation Area has the potential to produce in excess of 200,000 tons of stubble annually. Stubble is a renewable resource and often considered a waste product in the rice industry, making it a perfect candidate for value adding as a panel-board.

The selling points of the AMPAN board is that it is made with non-toxic, inert resins produced by the CSIRO meaning that it has zero harmful emissions, it is strong, moisture resistant, can withstand high flammable temperatures and posesses all the qualities of seasoned timber. All materials used to produce the panel-board are natural and non-allergenic.

John currently has a demand for 5000 tonnes of rice straw annually. This straw is collected shortly after harvest and processed in a local factory before being transported to major centres as the finished particle board product. A digram of the production process can be seen below.

The Economics:

Mowing, Baling	$532.00
Transport	$140.00
Preparation	$70.00
Processing	$6,220.34
Value of AMPAN	+$13,762.00
Total Profit ($/ha)	$6,799.66

Photo: Rice straw products, including the AMPAN particle board

AMPAN PRODUCTION PROCESS

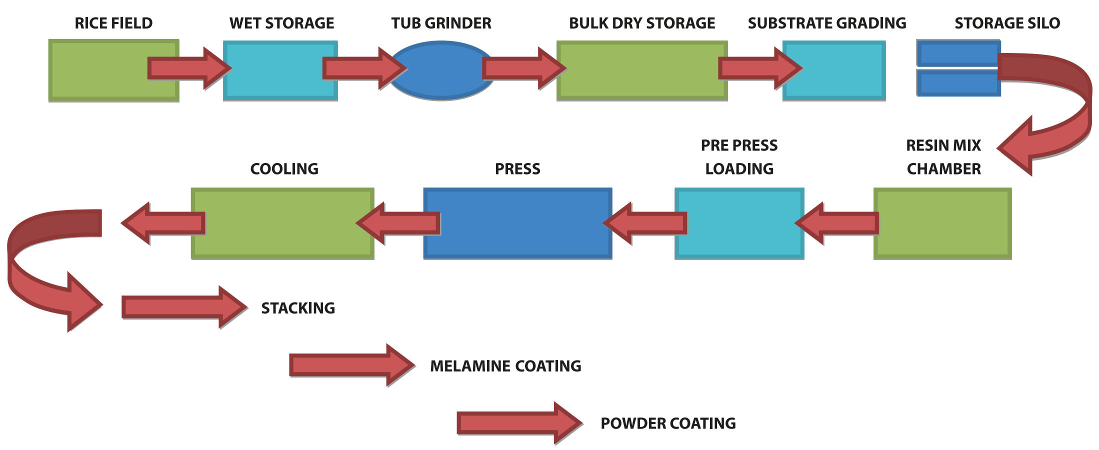

Diagram: The AMPAN production process from harvest to final product

Quick Facts:

Grower: Trent, Jenny & Chris Gardiner
Region: Coleambally Irrigation Area
Stubble Management: Removed from paddock
Next Crop: <1 month
Notes: Quality of product is paramount
Total Profit ($/ha): $1,575.00

Rice Straw Bale Homes

Using straw bales as a renewable building material has sparked interest for home owners who want a more energy efficient and environmentally sustainable home to reduce their carbon footprint.

Coleambally rice farmers Trent, Jenny and Chris Gardiner have recognised this opportunity and provide straw builder bales measuring 365mm x 450mm x 850mm through their website 'www.straw.com.au'. They also offer bales for stock feed, revegetation purposes and greyhound bedding and many other uses.

To market their building product, Trent and Jenny work with licenced builders, who specialise in natural homes made of straw bale and earth. Rice straw is the most popular straw for use in construction of these homes due to the significant amount of silica it contains. Silica adds density and resistance to decomposition and when constructed correctly, it is estimated that the walls will last at least 100 years.

Demand for this product has been growing 10-20% per year since the Gardiners first started supplying straw bales 33 years ago. Currently there is demand to produce 15,500 bales of Builders rice straw annually. Trent attributes the growing demand to the quality and consistency of the product they supply. He explained that growers need to provide a weed and dust free product that is repeatable, so quality control in the system is paramount. However, it should be noted that this is a niche market and can be easily flooded.

The Gardiner's also produce 12,500 bales of rice straw to supply revegetation projects in alpine nation parks. About 20% of these bales are used for erosion control and 80% used for revegetation of disturbed areas. Clients prefer rice straw as it does not contain weeds which are likely to thrive in alpine areas. However, it is still essential that straw provided is clean of weed seeds to prevent any sort of contamination of native areas. The Gardiners usually cart most of the orders themselves as drop off points are often inaccessible for usual transport companies due to the challenging terrain.

The straw is produced by first using a mower conditioner, immediately behind the stripper front header and then the straw is "tedded" up into a fluffy windrow before being baled around 8 days after mowing. The ground surface must be even to avoid mud contamination in the straw. Growers should consider that you will be baling in autumn weather and are have a higher chance of rain damage and bogging up the paddocks. There is a risk that some years weather will limit the number of bales produced so having carry over between years is recommended. All of our stacks are covered almost to the ground within 1 day of baling and All handling of the small squares is done mechanically until the truck arrives at the delivery site, where it is usually manually handled into stacks.

The Economics:

Mowing, Baling, Raking, Stacking & Tarping	$1400.00
Transport @ 500km	$1750.00
Value of Delivered Bale	+$4725.00
Total Profit ($/ha)	$1575.00



Photo: (below) Straw bale production from paddock to storage.

Other Options for Rice Stubble Management

Although this booklet has endeavoured to collate as many case studies for different applications or management techniques for rice straw, we were not able to include them all. There are many developing applications which are not yet feasible in Australia but are being trialled overseas, as well as some local examples that we were not able to include within the timeframes with which the booklet was developed. To ensure that these concepts do not go unacknowledged, we have provided a list below:

Rice straw for export markets

The rice industry is currently assessing potential for exporting rice straw to Japan for wagyu production. Australia has a competitive advantage over other countries due to being clear of 'foot and mouth disease".

Using aquaculture to speed stubble decomposition

In a rice-aquaculture rotation aquatic species are grown after harvesting of rice in the flooded fields without removing the rice stubbles. The stubble residue facilitates the growth of decomposing microbes which serve as food for aquatic species and enriches the water and soil with natural fertiliser for the next cycle of rice (Ramachandra Reddy & Kishori, 2018).

Extracting silica from rice straw

Rice straw is known to be particularly high in silica, which is relatively eco-friendly and only requiring low temperatures during the extraction process. Silica has a large range of applications and can be used to make glass, optical fibres, food additives, electric and thermal insulators, absorbents and pharmaceuticals. It can also be used to enhance plant nutrient delivery, to assist in preserving food and help fill gaps between carbon fibres for high strength, light materials for clothing (Quayle, 2016)

Using rice straw for erosion management

Rice straw mulch can be used in degraded sites to prevent soil erosion until plants are established. It is applied at a rate of 0.8 – 1.6t/ha by hand or with a mechanical blower. The straw must be anchored into the soil to prevent it from blowing away by crimping, disking, rolling or punching it into the soil; by covering it with netting; or by spraying it with a fibre binder. Straw wattles (9 inch wide by 8m long) are also being used to control erosion on steep slopes, they are placed at selected intervals along the face of the slope and pinned in place (Bainbridge, 1997).

Using rice straw for livestock bedding

Rice straw, hulls or densified pellets have been used for livestock bedding for intensive swine, beef and poultry production. In the case of swine, rice straw round bales are rolled out on top of hulls in pens. Pigs are removed from the pens after 16-17 weeks and the straw is collected and laid out into rows to start the composting process. The compost can then be returned to paddocks to improve long term fertility (Bull N.).

Rice straw substrate for mushroom production

In the United Kingdom 400,000 tons of straw was used in 1992 by the commercial mushroom industry and the amount continues to increase every year. The compost left over after the mushrooms are harvested is used for livestock feed and soil conditioner, increasing the economic value of straw (Bainbridge, 1997).

Bioenergy from rice straw

The rice industry is currently looking into anaerobic biogas production using rice residues as feedstock to run their mills and other equipment. Initial results are encouraging, but the overall feasibility assessments are still underway.

Considerations for Adoption

Ready to give up burning your rice stubble and adopting one of the methods described above? There are a few key points which should be considered first. While there are numerous benefits to retaining, removing or value-adding your rice stubble, there are a few common issues to be aware of:

- Nitrogen tie-up may be experienced following stubble incorporation. Adding stubble to the soil alters the soil C:N ratio, causing it to make nitrogen unavailable in the season after incorporation. Growers should be prepared to monitor successive crops and apply more nitrogen if necessary, to support growth.
- Retaining stubble may increase the weed burden of the paddock as seeds are not destroyed during the burning process.
- The risk of carryover for diseases such as rice Stem Rot is increased if stubble is retained and another rice crop is planted before stubble has broken down. Try to avoid planting rice on rice in consecutive seasons.
- Due to our dry environment, it is not unusual to experience a lack of stubble decomposition. Adequate amounts of moisture and nutrients are required for microbes to break down stubble, so not every year and every paddock will deliver the same result.
- Market size and development may hinder the success of some of the suggested value-adding methods such as creating composite materials or biogas. Many of the suggested value-add methods require more research and may be applicable only to niche markets.
- Rice straw has a low bulk density and this makes it quite expensive to transport. Activities that allow the straw to be value-added on farm can improve the economics of removing straw from the paddock.

For more information

If you would like more information on any of these case studies, please contact the Rice Extension team by emailing extension@rga.org.au or calling coordinator Troy Mauger on 0417 375 168.

For an electronic copy of the report visit the Western Murray Land Improvement Group Inc. website (www.westernmurraylig.org) and visit the 'projects', 'Alternative Uses for Australian Rice Straw' section.

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