

## **Prepared for the Farrer Oration 2010**

### **Australian Crop Production– A Story Of Ongoing Innovation and Adaptation.**

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#### **Introduction**

I wish to thank the Trustees of the Farrer Memorial Trust for this prestigious award. The ‘Farrer’ was never on my most distant radar and it came as a big surprise. To join the company of previous Farrer Medalists is a great honour. Without the support over decades of my family, friends and colleagues, the Australian grains industry, and the generosity of the Western Australian Department of Agriculture and CSIRO it would not have been possible.

This address will cover three quite different areas. Firstly, I will recognise the work of William Farrer and his magnificent contribution, not only as a great wheat breeder but also as the father of crop adaptation research in Australia. Then I will outline the development of zero tillage technology in Australia with technology stacking upon technology on the long road to its success. And lastly, I will use these as a springboard to consider the future possibilities for the biomass and bioenergy industries and the challenges which face them. I hope you will see the thread of adaptation and innovation weaving through these activities- it is the theme of this address.

#### **William Farrer**

William Farrer is famous as a founding father of the Australian wheat industry. While renowned for his wheat breeding efforts, and he is especially remembered for the development of the variety Federation, he might equally claim credit for being the first to apply rigorous scientific research methods to adapting crops to Australian conditions.

It is worth considering Farrer’s achievements and how he got there. He was born in England in 1845 and came from a fairly well to do background. He went to Cambridge graduating B.A (Hons) and gained prizes in mathematics, training which I am sure he found invaluable as he brought his keen and ordered mind to bear on wheat variety development in later life. He enrolled in medicine but contracted TB and decided to

abandon his medical studies. In 1870 he moved to Australia in search of a drier, hotter climate, intending to raise sheep. I guess he had worked out that he was poorly adapted to the damp English winters. He gambled on a mining venture, but lost his money so in 1875 he took a job as a surveyor with the NSW Department of Lands, something which suited his disciplined mind and mathematical talents.

As he moved around the NSW countryside he saw that imported wheat varieties were performing poorly and that farmers were suffering. Varieties were late maturing, fell over, were disease ridden, and were often of poor quality even if they did have names like Bagfiller and Farmers Friend. Australia was an importer of wheat and the infant industry was struggling with drought, wildly fluctuating prices and a labour force rushing off to the new goldfields. Perhaps that trio of challenges will strike a chord with today's farmers. James Ruse had started the first private farm growing wheat and maize at Parramatta in 1789, but progress over almost 100 years had been slow and difficult. Wheat production was mostly confined to high rainfall areas where modest yields were achieved but where diseases were often devastating.

Farrer recognized that imported varieties and local farmer selections were poorly adapted to Australian conditions and thought about ways to address the problems facing the industry. He got into a public brawl with the *Australasian* newspaper during 1882 about how to improve wheat. Controversy often sows the seeds of a new way forward and he later said this battle greatly sharpened his focus and his breeding aims. He read extensively around the topic and corresponded with overseas wheat scientists, and began collecting a wide range of wheat varieties from around the world. He bought a small property, Lambrigg, just outside present day Canberra and commenced his wheat selection and cross breeding work in a private capacity. He had, and I think this had much to do with his success, a very clear view of what was needed to adapt new varieties to the Australian environment. They needed to be early maturing so that they could perform in drier areas and under drought conditions; they needed to be shorter and have fewer tillers so that more investment went into grain (improved harvest index in today's terms); they needed to have stiff straw and be short to accommodate the rapidly improving Ridley

stripper and McKay harvesters of the day; they needed to be more tolerant of stem rust, bunt and smut; and they needed to have good bread making qualities to compete with imported wheat and in export markets.

His efforts were noticed and when in 1898 the NSW government wanted to appoint a wheat experimentalist to address the poor state of the industry, Farrer was an obvious choice. This increased the resources at his disposal and opened up access to experiment stations in drier climates. His protégé George Sutton, manager of the Cowra research station offered great support, carefully testing Farrer's selections for him. Sutton later came to WA, bringing Farrer breeding material with him, and this later led the release of the varieties Nabawa and Bencubbin which dominated Australian wheat growing from 1930 to 1950. In 1895 Farrer, using flattened hairpins as tweezers, made a cross which brought together European, Indian and Canadian material. From this he selected Federation releasing it as a variety in 1901. From first cross to release was only 6 years, something he apologized for as he recognized the plight farmers were in, but something today's breeders might envy. He also had a good eye for a catchy name as Australia had just become a federation and the word was on everyone's mind.

Federation proved to be superbly adapted to large areas of drier country and by 1910 it was the most popular variety in Australia, a position it held into the late 1920s. Farrer had an instinctive feel for what was needed to adapt wheat to the Australian environment and the evolving management systems of the time. He also recognized it needed to have good quality so it would sell and it needed to fit into farm systems and make money for farmers. He understood how genes, environment, management and markets (G:E:M:M) needed to come together if wheat production was to prosper.

He followed on with more varieties, but died suddenly in 1906, and is buried at Lambrigg. The Australian wheat industry expanded quickly from there. As a nation we owe Farrer a great deal. We should also remember his colleague, the cereal chemist Frank Guthrie who worked closely with him on grain quality, devising rapid screening techniques using small amounts of material. Farrer was a hard working, thorough,

practical scientist. His paper “The Making and Improvement of Wheats for Australian Conditions” (Farrer, 1898) which lays out his methods could be required reading for anyone setting out on a research path in agriculture. Those wishing to know more of Farrer and his work are directed to Guthrie (1922), Callaghan and Millington (1956), and Macindoe and Walkden Brown (1958).

When I read about Farrer’s life and his achievements after I was advised of this award I was struck by his passionate desire to adapt cropping technologies to the Australian environment not just in breeding better varieties but in understanding what he needed to change and why and then setting out very single mindedly to do it. He knew that he needed to address farmer profit and market needs and work with the Australian environment and crop management regimes of the day if he was to be successful.

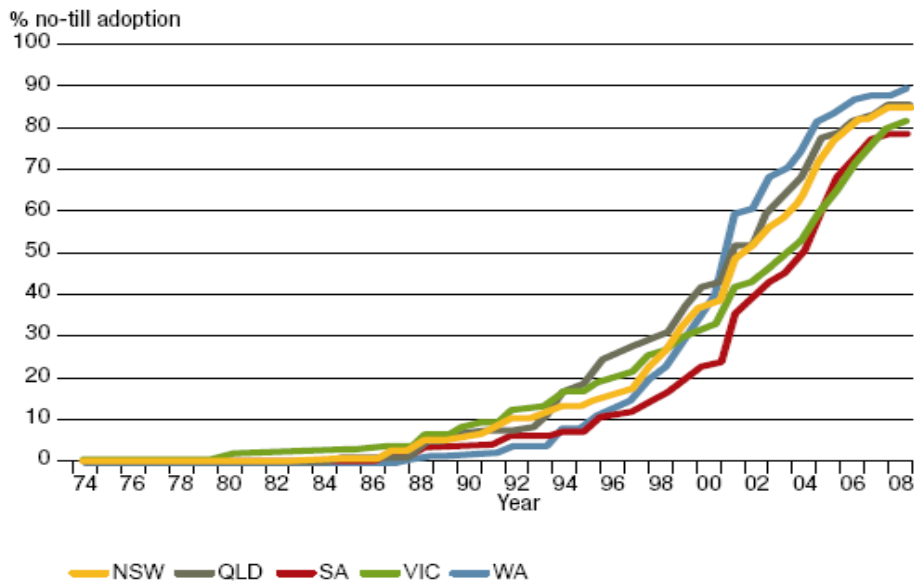
### **The No -Till Revolution**

I now wish to turn to a brief history of another revolution, the reduced tillage revolution, as an example of ongoing innovation and adaptation in Australian cropping methods. Going by many names -reduced tillage, minimum tillage, no-till or zero till- this development has extended over the past 45 years and is still being refined and adapted to changing circumstances today. When I left UWA in the mid 60’s and told a colleague that I was interested in crop research he replied ‘Why ? There is nothing more to do in cropping, you start ploughing in May, work back twice with a scarifier, and plant Gamanya on 15<sup>th</sup> June with 40 lb of seed and 90 lb an acre of super’. With the technology of the day that was probably fair advice.

But we were at the dawn of a revolution in crop production in Australia. Over the coming decades all that changed with reduced tillage techniques built around herbicide technology replacing the plough and scarifier. Llewellyn and D’Emden (2010) have examined the adoption of these practices using a broad definition of ‘sowing techniques with low soil disturbance and no prior cultivation’. Crabtree (2010) puts forward a slightly different definition ‘Sowing wheat without cultivation, disturbing less than 20% of the top soil’.

The figure below shows the remarkable growth in the use of these techniques and the typical adoption curve for new technologies, with a slow start then quite rapid uptake before finally approaching a plateau. Note this figure depicts uptake on the basis of percentage of farmers trying the technology, not area under these techniques.

**FIGURE 7** Cumulative adoption of no-till (decision to first use no-till) by respondents classified by state



(Figure extracted from Llewellyn and D’Emden 2010, by permission)

Llewellyn and D’Emden(2010) also provide estimates, below, of the actual areas under these systems in each state in 2008.

<u>State</u>	<u>Av. Proportion (%) all crop</u>
NSW	77
QLD (south)	75
SA	83
VIC	80
WA	92

This was not simply a single piece of transformational technology coming into play, although it is sometimes portrayed that way. There were a number of transformational

steps along the way, but it was the hard work of hundreds of scientists and technicians, and thousands of farmers over 40 years overcoming the obstacles as they arose which has got us to the level of adoption we have today.

But let us go to the beginning. While the concept of reduced tillage had been around since the 1930's it remained a dream. It took the discovery of the bipyridyl herbicides paraquat and diquat by ICI (Brian et al 1958) to open the way to serious research in these techniques. They were introduced to Australia in 1970 as the herbicide mix/ planting technique package "Sprayseed". ICI scientists teamed up with Departments of Agriculture and selected farmers to begin the task of adapting the technology for Australian conditions (Crook, 1984). Western Australia was seen as a good testing ground for the infant technology as the weeds were mostly annuals, the break of season relatively reliable and the lighter soil types were easier to handle. The situation in Eastern Australia was, and remains, more complex.

Over the next 10 years the teams tried many approaches to get the technology to work. They fine-tuned the herbicide mixture and worked on rates, times, spray technology and machinery configurations. Experiments were initiated which compared conventional cultivation of the day with zero till triple disc seeders and combines with various tine configurations. But weed control was difficult as there were problems with poor kill of subclover, large capeweed transplants and late emerging annual ryegrass. This led to the development of 'double knock' technology involving spraying, leaving for several days and then planting direct with a full cut combine. This gave mostly satisfactory results but it was a fair way from the Holy Grail of 'no till'.

There was much discussion around whether yields were comparable, whether nutrition requirements especially nitrogen were similar, whether emergence was satisfactory, whether pests and diseases were better or worse under the new system. While the technology showed real promise it was not sufficiently farmer friendly to take off as is obvious in the adoption curves (Fig 1). In another step forward, in 1970 glyphosate was discovered by J.E. Franz of Monsanto (Franz et al 1997) and released in Australia in

1978 as Roundup. Being a longer acting systemic herbicide it showed promise and later became a key component of no till systems. But annual ryegrass and wild oats remained a major problem as late germinations still avoided the spray treatments.

In 1971 the Hoechst company discovered the selective grass herbicide Hoegrass, began testing it in Australia in 1974, and it was released to industry in 1978 (Anderson 1978). I remember being given a small silver canister of this new chemical under its code name HOE 23408, amidst much secrecy, late in the season in 1977 and trying it on the only green ryegrass I could find, at Treeton near Margaret River in Western Australia. It was spectacular transformational technology and can be credited with showing the way to making the reduced till systems finally work well enough in farmer hands to begin the journey towards no-till farming. Many other selective grass killers followed. Also cheap broadleaf weed control– typified by the Diuron/MCPA brews – was appearing, followed by the sulfonyl urea suite of herbicides and other new molecules and mixtures. All these developments added to the arsenal farmers had to control the weeds which escaped the Sprayseed and Roundup knockdowns. There was now a solid foundation of technologies which allowed reduced tillage to work reliably. All this took place through the late 70's and 80's, but as you can see from Figure 1, uptake of the technology was slow as the chemicals were still relatively expensive and farmers had yet to put these developments together in cropping systems and gain confidence in their use.

The energy crisis of the 1980s and a gradual fall in herbicide prices and improvements in spray and establishment technology slowly started the shift towards wider adoption (Poole 1987). But many problems remained – rafts of wet straw caught under combines, concerns about nitrogen availability, and varieties not well suited to take advantage of the earlier planting times the technology offered. At about that time interest in stubble retention farming emerged across Australia and a new wave of research began to combine the reduced tillage technologies with retaining stubble. Those developments are still part of mainstream crop research today.

Straw choppers and spreaders became commonplace on harvesters allowing better machinery passage through straw in the following season. Most important of all narrow knife points or tines were introduced and configured on machinery in a way which allowed relatively trouble free no till planting into stubble. These developments have been reviewed by Anderson (2009). Large tractors, airseeders and massive boomsprays played their part. Now farmers had equipment where they could plant direct on the break of the season, and complete huge planting programs in a couple of weeks. The sum of all these developments, a combination of transformational and incremental improvements in technology, provided a new way of farming. Australia harvested the best of overseas and Australian innovation and adaptation to bring this about.

But the clouds were gathering. The first herbicide resistant weeds were found (Heap and Knight 1982) and it was recognized that repeated use of the selective grass weed herbicides in particular would lead rapidly to resistant weed populations. The no-till technologies were under threat and herbicide resistant annual ryegrass emerged as a significant problem, exacerbated by the recognition of multiple or cross resistance (Powles et al 1996). Research effort to tackle weed resistance commenced under the auspices of WAHRI (Western Australian Herbicide Resistance Initiative), now AHRI. Concentrated work over a number of years has been able to pull the problem back from being an industry crisis to being just another problem to face in crop management. The research community across Australia combined with the private sector to combat herbicide resistance and the work goes on as new resistant weeds are discovered.

By the early 1990s there was a sufficiently robust technology platform available, with cost and convenience factors underpinning it, for no - till to really take off. This was given a big boost by the formation of the No Till Associations, initially WANTFA in 1992 in Western Australia, and later similar groups in all states.

The tillage story is still work in progress. The debate about points versus discs for crop establishment stirs emotions as does the role genetically modified crops might play in these systems. Other problems have surfaced. The ability to plant large crops in a short



time near the season's break has opened up large frost risk problems. Frost is one of the largest unresolved problems facing Australian grain growers. It deserves the Farrer treatment whereby all aspects of genes, environment and management are explored for solutions.

To tell the whole zero tillage story would take hundreds of pages. The list of contributing people when we include farmers would run into thousands. I think it shows the remarkable ability of Australian farmers, scientists and agribusiness working together to take up technological advances and adapt them in the Australian context, and stack them, to build whole new and profitable ways of farming. It is a great unfinished story. The reason for dwelling on it is to underline the long time periods required to bring whole new farming systems to fruition, to stress the importance of taking the best of international developments and to adapt them for Australian conditions, and to look at all aspects of genes, environment, management, and markets as technologies are stacked to take us forward. It has been a privilege to be one tooth in one of the many meshing cogs that make up no till cropping technologies in Australia today.

### **Biomass for Energy**

In the third part of this address I wish to turn to the emerging biomass/bioenergy industries which may be worth billions of dollars to Australia in coming years- or maybe they will come to nothing much at all. Today these industries are perhaps where the wheat industry was all those years ago when Farrer set out on his epic journey, or where no-till technologies were in the early 1960s. They seem to be full of promise and to fit with the needs of the world but are beset with challenges and uncertainties. Whether biomass becomes an important part of the energy mix will depend on our ability to adapt and adapt again to changing circumstances, all the way from paddock management to informing the highest levels of government policy.

The interest in plant biomass for energy is driven firstly by the idea of peak oil and a world running short of fossil fuels, especially liquid fuels, and the price hikes that would cause. Secondly by a desire to combat the greenhouse effect and climate change by

reducing CO2 emissions. I am not going to go into the big world debates on those issues, they are very much in the mainstream media and today form part of everyone's daily experience, and they are beyond the scope of this address. I will explore just two emerging biomass opportunities in Australia's cropping regions, cereal straw and mallee biomass.

***Straw as a biomass resource.***

We have just left a discussion of zero tillage techniques, where, you will recall, we saw the efforts to marry no till technologies with retaining stubble, so the idea of harvesting straw for bioenergy may at first glance seem to be quite at odds with retaining stubble.

We put a lot of effort and money into growing a wheat crop, but on average harvest and sell only a little over one third of it, the grain fraction. The rest of the above ground material is stalks, leaves and chaff. These components are of course not just waste material, as they protect the soil from wind and water erosion, add nutrients and carbon to the system, and feed sheep amongst other things. But much of this residue material goes back to the atmosphere as CO2 as microbes and UV light degradation break it down in the months following harvest, or it is burnt as part of preparation for the next crop.

Is there an opportunity to take some of it away as a source of energy or will we destabilize cropping systems so much that we should not go down that path? The debate is worth having so let us briefly explore the issues.

Firstly, how much energy is there in straw, is it in a useful form and could it make a significant contribution to the future Australian fuel mix? Straw is made up of cellulose (43%), hemicellulose (28%), lignin (16%), ash (9%), and volatiles (4%) on a dry basis (Pearce et al 1987) and is very similar to wood. In the paddock in summer it may contain 7-12 % moisture.

There are three main paths it might follow as a potential energy source. Firstly it can be used as it is to fire boilers for say power generation or boiler steam for industry in

regional areas of Australia. This is well established technology with steam and electricity generation from bagasse being a normal part of modern sugar mill technology. Secondly it can be treated by slow or fast pyrolysis, that is cooked in reduced oxygen conditions, to form a gas or liquid fuel which may substitute for fossil fuels. Thirdly, it can be treated with enzymes to break down the cellulose and hemicellulose chemical bonds releasing their component C5 and C6 sugars, making them available for fermentation to produce ethanol. These latter technologies are under intensive research effort world wide and while rapid progress is being made they are not yet fully commercial. The pyrolytic path is relatively well advanced and is making a contribution while the enzymatic path is a bit further out into the future.

While the technical obstacles are still large, they are steadily being overcome, and the cost and efficiency of conversion is improving. In the end their future as contributors to the fuel mix will depend upon whether they are able to form the basis of profitable businesses. Clearly as the prices of fossil fuels rise the bioenergy technologies come into the picture, but at present they require significant government support via a mix of tax and excise breaks and mandated inclusion levels at the pump to make them viable. Many countries now have forms of support in place to encourage renewable biofuels, too detailed and complex to consider here. Australia likewise has incentives at both Commonwealth and State level, with incentives differing between states. However Australia is struggling to meet its self imposed goals and mandated inclusion levels.

Further issues which are the object of extensive debate are net energy and atmospheric CO<sub>2</sub> amelioration from using biofuels. When everything is taken into account will using straw in this way be much better than continuing to use fossil fuels? Sophisticated life cycle analysis (LCA), a kind of cradle to the grave comparison of alternatives, is used to compare technologies. It requires energy to harvest, transport and convert straw or other biomass to biofuel and this needs to be set against the process in the total energy sum game. An example of this kind of analysis for straw for fuel is given by Farine et al (2010)

One tonne of straw can be converted to provide 335 litres of ethanol. Ethanol has 68% of the energy or calorific value of fossil fuel based petrol so in broad terms, one tonne of straw can provide the equivalent of 228 litres of petrol. Ethanol is widely used around the world as an adjunct to petrol and from a car engine aspect nearly all major manufacturers accept it at specified levels, with 10% being common. Brazil uses much higher levels, 25% is mandated, and cars have been designed to use up to 100%. Nearly all the bio ethanol in use at present is made from sugar or starch based grains where the sugars are readily available for fermentation. As stated earlier, the lignocellulosic conversion technologies using wood, straw, bagasse and similar materials, often called second generation technologies, have a way to go. However from a technical viewpoint they are slowly getting there as large resources are devoted world wide to their development. Enzymes are being sourced from several organisms known to break down lignocellulosic products, and termites and wood rotting fungi are examples. Warden and Haritos (2008) provide a view of the status of these technologies from an Australian perspective.

For Australian broadacre crops, after removal of grain, how much residue remains? Harvest Index, that is the proportion of total above ground biomass which is grain is well researched in Australia and typically is around 0.36 for wheat and barley (Unkovich et al 2010). HI provides a means of deriving straw production in Australia, as grain production statistics have been compiled on a Local Government Statistical Area basis for many years. Assembling data from these sources Dunlop et al (2008) have derived straw distribution on a geographic and seasonal basis. In Australia we produce around 40 million tonnes of grain annually. Using harvest indices and grain statistics for all crops in an 'average' year, total non grain above ground biomass production is about 70 million tonnes. If we were able to take all of this biomass and convert it to ethanol, we could meet around 75% of Australia's current petrol use of 20 billion litres. However physical and sustainability issues stand in the way of complete removal.

Putting aside sustainability for the moment let us look at the morphology of the wheat plant to see what, in a physical sense, we might be able to harvest. Australian wheat crops are typically around 70-75 cm tall. The hay and straw industries use a notional 'beer can'

height of 12.5 cm as the minimum height above ground they can cut without damaging equipment. Also, dry matter at maturity is not equally distributed over the height of the plant, with proportionally more material near the base where stems are thicker, and as a result approximately 30% of the stubble is below the 12.5 cm cutting threshold. Putting these numbers together we are able to derive a 'physically harvestable' national biomass figure of 50 million tonnes. On a crop basis for a typical 2 tonne/ha wheat crop producing 3.6 tonnes of non grain material and applying the 12.5 cm constraint, physically harvestable amount is 2.6 tonnes/ha. We are now down to meeting a bit over half of Australia's petrol needs on an equivalent basis. Remember this is a physical removal quantity, not constrained by sustainability requirements or economic realities.

When those constraints are introduced the picture becomes less clear. The sustainability issues include *inter alia* – amount which should be left for wind and water erosion control, nutrients removed in straw which might otherwise be available for subsequent crops, soil carbon dynamics and impact on water conservation. In the economics realm the cost competitiveness of harvesting the straw and getting it to a conversion plant compared with other fuel sources and the requirement of sufficient profit for farmers to induce them to part with the straw are important. Looking at these briefly:

- *Wind and water erosion.* Work over many years suggests that for southern Australian cropping systems, at least 1 t/ha of straw mostly attached to the soil by dead root systems, is required for soil protection (Carter 2002). In northern eastern Australian cropping zones where rainfall is more intense, soils heavier and slopes greater, between 1.5 to 2.0 t/ha is recommended. For a 2 tonne/ha grain crop the harvest regime of cutting down to 12.5 cm will leave about 1 tonne/ha of attached straw, so this may be satisfactory. In higher yielding crops it will be easily met, in lighter crops removal may not be advisable as erosion thresholds are breached.
- *Nutrients.* Straw contains nutrients. Typically a tonne of grain and a tonne of straw contain the following nutrients (in kg) - Nitrogen grain 20:straw 5, Phosphorus grain 2.5: straw 0.5, Potassium grain 4:straw 10, Sulphur grain

3.0:straw 0.5. Much is known about crop nutrition and what needs to be applied to grow a healthy grain crop and we have extensive experience of nutrient requirements for the present hay and straw industries. Nutritional aspects may be technically manageable and a decision to harvest straw from this aspect is likely to come down to economics. For a particular situation does the cost of replacement of nutrients to maintain yields outweigh the return and cost associated with straw harvest? Potassium may cause most concern as it is removed in large amounts in straw and is costly to replace.

- *Carbon.* This is a vexed issue. Carbon cycling is important in greenhouse gas balance assessments. There is much debate and conflicting information about soil carbon accretion under different cropping systems. Soil carbon may steadily decline under intensive long term cropping. In some circumstances it will build up slowly under some stubble retention systems. We also know that soil carbon can rebuild quite quickly with pasture leys and that soil C : N ratios are important for soil health. See Baldcock (2010) for a discussion of these processes in an Australian context. However we have poor knowledge of two very important aspects. Firstly, if we take away a proportion of the stubble for energy use, say a half, what will the impact be on soil carbon and can we manage it in a cropping system sense? Secondly, we have poor knowledge of carbon dynamics at and near the soil surface in no-till stubble retention systems. How much carbon, if any, will accrue to the soil from undisturbed surface straw and how will it get there. Work is just beginning on these issues and it is a very fertile ground for research. They are key gaps we must fill in the pyramid of knowledge as straw biomass for bioenergy technologies go forward.
- *Water retention.* Retained stubble can potentially conserve water via three mechanisms – by reducing soil evaporation, by reducing raindrop impact and soil sealing allowing water infiltration and by preventing overland surface flow. At the stubble levels likely in most Australian broadacre cropping systems reduction in soil evaporation over long hot summers appears to be of minor importance. The

other factors are important and the question remaining is whether the stubble left behind after straw harvesting is sufficient to meet infiltration and prevention of overland flow needs.

In summary, we have a picture for a typical 2t/ha grain crop where harvesting the straw at 12.5 cms still leaves sufficient material for soil protection, the nutrient issues are manageable and come down mostly to cost and there is probably enough straw for water conservation. However in these partial removal situations many questions remain about the carbon balance. Clearly circumstances will vary from farm to farm, paddock to paddock and local advice will be essential.

Straw is widely and readily available in grain growing regions. It is already partially harvested in normal grain harvest operations and then returned to the paddock from the back of the header. Opportunities exist to modify harvest operations to gather more straw. For example as part of herbicide resistance management straw baling technologies were developed to catch weed seeds. These technologies have been further refined by the Shields family of Wongan Hills in their Glenvar Direct Bale systems where it is possible now to cut at close to 12.5 cm, retain the wheat grain, and bale the straw and chaff as part of a one pass harvest operation then use modular pickup and stacking technology to deliver it onto trucks for direct delivery to a local or regional bioenergy plant. A video of the Glenvar bale direct and straw accumulation and transport operation is available via Google at You Tube Harvest

Is this a new income opportunity for farmers and an energy feedstock option for regions? Most of the technical elements are there but we need a lot of fine tuning, some new knowledge and the right economic settings if energy from straw biomass is to become a reality. The coming decade should decide its future.

### ***Energy Tree Crops***

In the early 1990's oil mallees began to be promoted as a multiple product/multiple benefit plantation crop integrated with existing southern Australian farming systems. The

history of the development of the industry and a list of products and benefits has been summarized recently (URS Australia 2008) as:

- Eucalyptus oil
- Composite wood products
- Biofuel
- Bioelectricity
- Activated carbon
- Sequestered carbon
- Salinity amelioration
- Windbreaks
- Bioversity

Over the past fifteen years extensive research and farmer experience has resulted in a plantation configuration aimed at reaching a balance of the mallee and cropping components in an integrated farm system. Apart from economics, practical matters of crop machinery access and maneuverability must be considered. Twin row mallee belts, with about 80 metres between belts sown for grain crop production and where mallees occupy about 7 to 8% of the paddock is settling as a desirable configuration, with some variation for different soils and rainfall regions (Abadi et al 2009, Bartle and Abadi 2010). Mallee belts are now a common sight in the Western Australian wheatbelt and they are beginning to receive some attention in Eastern Australia.

The mallee industry has gone through periods of expansion and 'resting' and is still small (URS 2008) At present it is in a resting phase, due to uncertainty about carbon policies, the global financial crisis, drought and some unresolved technical issues.

In recent times there has been most interest in two aspects, as a carbon sequestration opportunity and as a source of feedstock for bioenergy and byproducts in regional areas. Extensive technical and economic analyses of supply chain scenarios from paddock to factory or generator door have been completed by the Future Farm Industries CRC in conjunction with the private sector.



The value of mallee as a carbon sequestration opportunity at the farm business level in Australia depends upon the development of a reasonably stable carbon market. If a sufficiently high price eventuates for sequestered carbon mallee may take a place on farms for this role alone, but it may be that sequestration by itself will be insufficient to encourage large scale plantings on agricultural land. The multiple markets and benefits outlined earlier may need to come together to provide the necessary incentives.

A long recognized major hurdle to a successful production system is harvesting and delivery at a price which will induce farmers to produce the crop. Mallees by their nature are tough, many stemmed and twisted and present unique harvesting challenges. Unless mallee can be harvested and delivered at a price competitive with coal or diesel, or a percentage of renewable fuel use is mandated by governments, then it will struggle to make headway against relatively cheap and convenient fuels. Work on a mallee harvester prototype began in the 1990's and while a valuable start was made it did not result in a commercial machine. The CRC for Future Farm Industries working closely with industry, government and the Oil Mallee Association is endeavouring to produce a 'one pass' harvester which will reliably harvest and chip biomass initially at 20 tonnes/hour and hopefully later at 50 tonnes/hour, on a 50% moisture basis. This work is the subject of intensive research.

The systems proposed rely on coppicing mallee, that is, harvesting it and letting it regrow for another harvest, and another. The present proposal suggests a first harvest at five years and coppice harvests every three years or so from then on. Questions remain about the water and nutrient dynamics of such systems and research has begun on this issue. Some questions still remain about mallee as a fuel for power generation, and what options exist for taking a further step and using pyrolysis techniques to produce liquid fuels.

The mallee biomass industry is typical of many emerging industries in that it faces a chicken and egg situation. If there is no established and reliable market farmers will be

reluctant to grow and harvest it, while if there are not commercial quantities and a reliable stream of feedstock, power generators or other end users will be reluctant to make the large R&D and capital investments required to bring the technologies to economic reality. Farmers in Western Australia have been bold in planting areas of mallee at commercial scale, as have research and energy agencies in putting money and effort behind the industry. The pilot mallee powered electricity generation plant at Narrogin was a bold step forward.

Governments have a large role to play here in firstly setting policies which will provide the economic incentives for these fledgling industries to develop and secondly to invest directly in R&D to solve the many technical issues remaining. Governments have been forthcoming in these areas but more is needed. The road is long, and Kramer and Haigh (2009) argue that new energy technologies take decades to become established and significant front end investment by governments in research and development and pilot plants has been required to catalyze new energy industries.

While showing promise, many hurdles must be overcome before the industry is fully adapted to local circumstances and is able to play its part on farms and in renewable energy supply in regional economies. Steady work over years is required to solve the technical and economic obstacles and stack the technological advances just as such effort was required to bring reduced tillage to fruition.

Cereal straw and mallee belts are grown side by side by farmers in broadacre cropping systems in Australia. What is still on the drawing board but beginning to receive serious consideration is the possibility of bringing the two sources of biomass together as complementary biomass feedstocks for energy production in regional areas. The straw is there and available now with all the caveats mentioned earlier and may provide a cornerstone to build from while the mallee industry solves its problems and reaches critical mass. At present the two sources are seen to be somewhat in competition but a future where energy companies can draw on each source and use one to buffer the other

may be the way ahead. Mallee is a perennial tree crop, and while a very quick one by most tree crop standards, it requires patience, courage and a compelling business case for farmers to invest on a significant scale and it will be years yet before it is available in large quantities.

### **Concluding remarks**

I set out to describe how Farrer saw the need to quite drastically change wheat varieties to suit Australian conditions. He had a clear vision and a detailed plan of how to arrive at the fulfillment of that vision. I then used the tillage revolution to show the timescales and complexity of effort required to bring about a major change in farming, with again a need for clear vision, patience and sustained effort as technological advances were stacked to provide a way forward. Then I considered two elements of the emerging biomass energy, straw and mallee, as they relate to present day farming and the opportunities and challenges which we face to bring these to reality at a commercial scale. Farrer would, I am sure, approve of our innovation and adaptation efforts. But I am equally certain he would keep hammering home the need to bring together those essential elements of genes, environment, management, markets and economics to achieve the dream.

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