AUSTRALIAN NUFFIELD FARMING SCHOLARSHIP

The study

RICE GROWING AND IRRIGATION PRACTICES

- BREEDING AND TECHNOLOGY
- WATER USE EFFICIENCY
- WATER POLITICS

Report by

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1. Acknowledgements

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2. Executive Summary

The Australian rice industry is facing many challenges, including water availability and reproductive cold sterility. I took up the Nuffield challenge to travel the world to see how other rice producers were facing up to and meeting similar challenges. I set out to look for fresh ideas in rice plant breeding and technology, water use efficiency and water politics. These became the basis of my study.

My study tour led me to the following conclusions:

Breeding and Biotechnology

Genetic technology will offer the tools to help solve cold sterility problems. I believe the Australian rice industry needs to continue work on finding these tools to pass on to our own plant breeders, while at the same time working to create a more enlightened consumer environment.

Water Use Efficiency

Australia seems a long way ahead in acknowledging and dealing with water use issues in rice production. But we should continue our on-farm efforts (e.g. looking for better after rice crop rotations) while looking at new areas like aerobic rice production.

Water Politics

I believe water will continue to move from agricultural production to urban and environmental use. We need to make sure we have a role in managing this change, by working in partnerships with all groups to ensure the survival of our industry.

The Nuffield tour was split into two sections: the first being organised by the Nuffield Association and the second my individual study. The organised section of the tour included Nuffield scholars from England and Australia and took in Singapore, Indonesia and The Philippines where we were given a broad view of trade policies and opportunities, as well as looking at many cultural features and agricultural operations. The experience was an eye-opener, widening my understanding of Australia's role and opportunities in the region. We

left South East Asia with images of 20 people working in a 2 acre corn field and headed for California where we saw a family company growing, processing and marketing 40,000 acres of carrots. It certainly gave us an interesting perspective on agriculture. I took particular interest in California's reliance on irrigated agriculture. In Canada, we experienced the Ontario region through a real taste of Nuffield hospitality. Our final task as a group was to visit Washington and Brussels to be given an insight into agriculture and trade policy.

The main part of my study tour took me to the rice growing regions of: California, Louisiana, Arkansas, Texas, Mississippi, France and Italy for a more in depth look at rice production and associated water issues, through my three chosen topics.

The recently completed mapping of the rice genome has added impetus to rice breeding programmes wherever I visited. I saw some of the tools of biotechnology already at work (marker aided selection for grain quality).

My studies into rice water use efficiency were at times frustrated by a lack of real measurement data of on-farm water use, though more efforts in this area were starting to become evident. Most of the regions I visited had looked to address water use efficiency via breeding programmes alone (e.g. shorter growing seasons), rather than in conjunction with on-farm initiatives.

The politics of water certainly led me into many interesting debates - who should or shouldn't have access to water, every one has an opinion.

I would like to finish by thanking the Nuffield Farming Scholars Association for a unforgettable opportunity to travel the world, make some amazing contacts and learn. I also need to thank most sincerely, my sponsors; PIBA, Gresham Partners and Incitec, and finally, my friends and family who made it possible for me to take part in this experience.

3. Introduction

Rice has been grown commercially in Australia since about 1869. Production started in Queensland and spread to New South Wales, Victoria, Northern Territory and Western Australia. Since the mid 1920s, production has been centred on the Murray and Murrumbidgee River valleys of New South Wales, which now produce ninety five percent of Australia's rice.

2500 family farm businesses produce rice and other foods and fibres. In 2000, 150,000 hectares produced 1.4 million tonnes of rice. The average yield of 9.3 tonnes per hectare was grown with an average water use of approximately 14.5 megalitres per hectare or 650kg of rice per mega litre.

Most of the water for rice production is supplied from storage dams upstream on the Murray and Murrumbidgee Rivers. Availability of this water for rice production has probably peaked around the mid to late 1990s. Development downstream, particularly on the Murray, demands for urban and industrial use, environmental flows and water quality issues look set to reduce the rice industries access to water.

The rice industry is vertically integrated, producing, receiving, storing, processing and marketing 99% of Australia's rice, through a grower-owned co-operative. It currently exports 85% as branded product to over 40 countries, the remaining is 15% sold domestically, all under the "SunRice" brands.

The two main limiting factors in Australian rice production are:

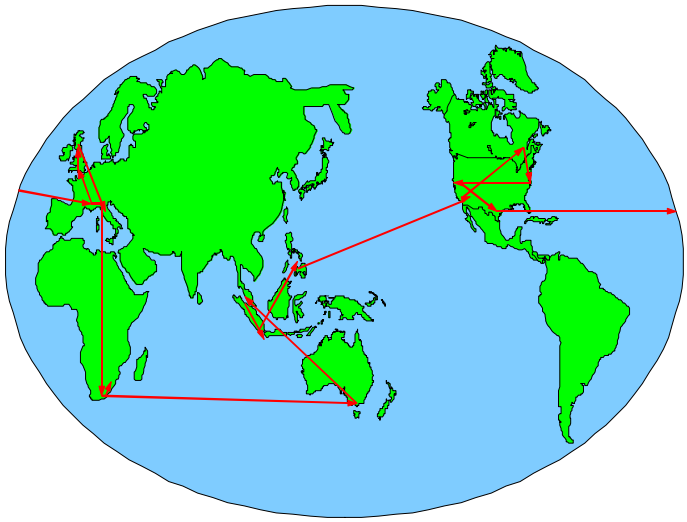
- water availability
- reproductive cold sterility.

I chose to look for solutions to these issues by undertaking my study of Rice growing and irrigation practices by concentrating on:

- breeding and technology
- water use efficiency
- water politics.

As part of Nuffield's organised Asia and North America tour, I was able to visit the International Rice Research Institute (IRRI) in the Philippines and look at how these issues,

particularly breeding, technology and water use were being addressed there. I further investigated these and other issues in the USA, France, Italy and Mozambique. Unfortunately, I had to change plans with regards to going to Egypt after the 11th September bombings in the United States. Below is a map of my study tour, commencing and finishing in Melbourne.



The first six weeks of the tour was spent travelling with Nuffield Scholars from around the world and took in Asia, California, Canada and Washington DC. This was then followed up in England and Brussels a few weeks later. I returned to California to study the rice industry there and then moved down to the Southern States to continue my research. Before rejoining the group in England, fellow Nuffield Scholar, Russell Ford and I attended the French Rice Research Conference, in Arles. Following the organised section of the tour, my wife, Aileen, was able to join me. We took a week's respite in Scotland (where I met my Father-in-law for the first time!), before recommencing rice meetings in Italy and France. Aileen then returned to Australia, while I concluded my study tour in Mozambique and South Africa.

Although each of the rice growing regions visited on the tour seem on the surface to be very diverse and unique in many ways, they each still face many of the same problems and issues. Diseases (such as Blast) and weeds (such as red rice and barnyard grass) effect crops and yield almost everywhere. Researchers around the world are working on using breeding and technology to control and hopefully eradicate these. Similarities can also be seen in the quest to increase yield, improve cold tolerance and to find the grain that will produce the perfect cooking result each time. Each group of scientists is looking to improve the farmers' lot and meet their respective environmental and market demands. Stubble burning and chemical use raise the same arguments in Italy as in California; red rice creates similar concerns in France

and Arkansas and cooking qualities are as important in the American restaurants as they are in the Italian Ristorante. IRRI steps beyond mere market requests and is looking at the newly mapped rice genome to enhance rice production for Third World consumption. Breeding and technology has an important role to play in all aspects of rice production and therefore a large portion of my study is based on this.

Water usage, with the resultant political arguments, is becoming a problem more and more around the world. With increasing urban and industrial demands, rice growers are having to compete for limited water supplies. Top scientists are working on plant water use efficiency and growing technique in order to overcome these difficulties and many of the rice growing countries are now finding it necessary to establish more accurate water use measurement techniques. My report will look at some of the current systems in place around the globe and the steps each is taking to improve water usage.

Water is a very contentious topic. Australia is not the only country in the world that has extensive political debates on this issue. Whether water is limited or in abundance, the water argument has a familiar ring to it. Non-agricultural demands and the environmentalists are having a stronger influence on water usage. I decided to include a look at the politics of water to see if the debate, currently underway in Australia, can be helped along by the experience of others.

It is impossible to do such a tour and not learn more than the study topic. Talking to experts in theirs fields leads to new learning and interesting ideas and concepts, new ways of approaching problems. I have included a chapter in my report to include those things which fall outside my area of study, but which I feel are worthy of special note. I have also added a list of interesting websites, which are of particular interest.

4. Breeding and Technology

Cold sterility at the rice reproductive stage causes major yield losses to occur one in five years in Australia. Cold induced pollen sterility can decrease yields up to 50% in the worse cases, but also causes some smaller percentage losses in many years. This problem also occurs in other temperate rice growing regions throughout the world. To date, our conventional plant breeding techniques have been relatively unsuccessful at producing solutions. Temperatures of around 16 degrees Celsius start to produce spikelet sterility, which increases in percentage damage, as temperature drops. The duration of the temperature drop also has a bearing on the percentage of sterility.

Australian rice producers are currently encouraged to try to insulate against cold damage by lifting water levels to 20cm and above at the cold sensitive stage, as it takes much longer for the water temperature to drop than it does the air temperature. Most temperate rice producing countries have some problems with cold sterility at the reproductive stage and some even document cold damage at seedling establishment. Cold sterility affects other management decisions such as time of sowing, fertiliser applications and rates and water management.

IRRI

IRRI, the International Rice Research Institute, in Los Banos, Philippines, is part of CGIAR the Consultative Group of International Agricultural Research. IRRI was part of a worldwide effort to study the rice genome and as a result, rice is the first genome to be fully mapped and will be used as a template for all other cereal crops. IRRI's charter is working in partnership to feed the world's growing population and sustain fragile environments.

As a rice grower, the visit to IRRI was a major highlight of the organised Asia and North America Nuffield tour (although a week of rice research proved to be a little much for some of my fellow Nuffield Scholars). To be able to meet with people like Dr. G. S. Khush, principle plant breeder and Nobel Prize winner, and discuss his work was a rare opportunity indeed. Dr. Khush made it clear to our group that he has no doubts that science can feed the world. IRRI's projections have the world's population stabilising at about 9 billion in 2050. IRRI is conducting research across all areas of rice science, production and extension.

At IRRI they are just starting to look at water use efficiency versus yield per hectare via a study of aerobic rice production. It will be looking at things like: - dry direct seeding, reduced water depth, saturated soil culture and alternating wet and dry. It will also be investigating

drought tolerance work done in China, with the hope of producing a 'New Production System for Aerobic Rice'.

In December 1998, a workshop was held at IRRI to look at genetic improvement of rice for a water limited environment. It had identified what had been done to date and also which new tools coming out of current research may be useful in the future. We learnt while at IRRI, that with a full understanding of how the newly mapped rice genome functions, which is the next phase of research being undertaken, we should see advances such as vitamin A enhanced rice. IRRI's Dr. S. K. Datta was also working on transgenic rice – BT rice and Golden Rice – added beta-caratin. Dr. Khush was working on a new plant type, Super Rice – more grain less leaf, larger panicles, normal sterility and good weed suppression. Interestingly, one breeding issue that has proved difficult for Australian rice breeders and also at IRRI is that of rice fragrance. Dr. P. Virk believed that strong growing environment influences such as cooler temperatures at certain plant stages may enhance fragrance.

One of IRRI's major goals is the training of people. Madeline Quiamco, IRRI's head of training, spoke to us about the training of individuals, groups, trainers and extension officers and the difficulties of matching materials with changing technology. They run web-based publications and decision aids, video conferencing, online courses, along side a two-week rice production course, in which you learn how to plough behind a buffalo. One of the biggest problems is that scientists are still reluctant to work in training. We talked about the way our Australian CRC (Co-operative Research Centre) works at bringing both students and scientists in contact with rice growers. They are also looking at various forms of distance training, in which Australia has a lot of experience and knowledge.

While we were at IRRI we visited the Philippine Rice Research Institute (PhilRice) to look at the local Philippine's rice breeding programme. The Philippines has 5 million rice growers growing 3.2 million hectares and helping to feed a population of 75 million people. Although their facilities were spartan in comparison to IRRI, they appeared to be achieving very good results. They also appeared to have a very good relationship with local farmers, even using farmers to help train graduates in better understanding their needs.

Whilst at IRRI we also visited local farmer Sesinando Masajo, who showed us around his farm. Even on a small scale such as his, he showed the benefits of diversity and innovative thinking to help keep him ahead of his peers. His seed production techniques, chemical free sustainable farming and diversity into things such as ornamental plants were a highlight. But even the best must have failures, evident by his empty fishponds.

Dr. Martin Mortimer, Head of Weed Ecology at IRRI, is working to come up with protocols for the plant breeders to better understand and utilise the weed versus rice, growth and competition patterns. He also mentioned that IRRI had stopped work on allelopathy. They had some success in the laboratory but ran into great seasonal variations in the field. The science was also very hard to prove and may even just be competitive suppression, all very similar to our Australian experience.

Overall, the visit to IRRI was a great opportunity to see first hand some major advances in rice research and showed that IRRI was certainly reaching for some of its goals, as countries like Vietnam were now self sufficient and becoming net exporters using IRRI varieties and technologies.

FRANCE

The French rice growing region in the Camargue area is constrained by cold temperatures at sowing and also by cold temperature induced floret sterility. I met with Jean-Claude Mouret of Institut National de la Recherche Agronomique INRA at Montpellier, who has been working on modelling software tools to help French rice farmers try to reduce risk associated with cold. As the French have only a small rice plant breeding programme (and in fact get many of their new varieties from other countries) it will be some time into the future before they can address the issue of cold sterility through breeding. As a consequence, Jean-Claude's approach of risk and uncertainty management tools seems to be working to help growers pinpoint best case timing of major dates e.g. sowing to minimise the dangers of cold sterility along with other agronomic issues.

While in the Camargue, we met with Cyrille Thomas, who is the Director of the Centre Français du Riz (CFR) in Arles. He explained that the Centre was opened fifteen years ago as a response to rice dying out due to consumers no longer wanting the short grains that the French were then producing. The Centre's role is advice and support, conducting experiments and field trials, and managing an extension programme. It is a small team of only five, but they work closely with other scientists from INRA and CIRAD (Centre de cooperation Internationale en Recherche Agronomique pour le Developpement). The Centre is funded mainly by government, with about 5% coming from growers.

French rice production is unique in that two thirds takes place within the Camargue, which is a national park. CFR is working with a private conservation group, Tour du Valat, on how the Camargue's other unique feature, pink flamingos, coexists with rice production. They are also trying to assess the benefits, or otherwise, organic versus conventional production

systems. They are studying ten fields of both to see which production system promotes a better food chain for wildlife.

The French breeding programme is quite small and is heavily focussed on long grain production. The cold winds, La Mistral, put many limits on both the geographical range and the seasonal timing of rice growing. Using conventional breeding techniques, they are trying to produce shorter growing season varieties that can be sown between 20th April and 10th May and still flower before 10th August. Because of the cold at establishment, they are looking for varieties with good seedling vigour. Like the Australian rice industry, the French farmers have decided against using transgenic rice at this stage and as a consequence all genetic work must be done independent of the industry by CIRAD.

France only produces about a third of its current consumption. Cyrille has hopes its new breeding programme can help lift production. Currently, about 50% of seed comes from Italy (it has quality problems like red rice). The grower co-operative that used to run the breeding programme has now taken on the role of pure seed build up of CFR lines.

The issue of EU subsides is very important in the French farmers decision-making process. Fellow Nuffield Scholar and rice grower, Russell Ford and I were able to attend the French Rice Grower's Conference in Arles. Our understanding of some points was hindered by our limited knowledge of the French language, but there was no mistaking the mood at the meeting when the EU representative got up to speak about change to EU rice subsidies. The level of angst and blood pressure rose alarmingly and helped to lift our level of understanding. The EU considers rice differently to other grains, most of which have at least a 10% land set aside clause. Rice does not. The subsidies take many forms, one of which is a minimum price top up scheme. As we were told in Brussels, the EU is trying to move to a more environmental system of subsidy; as a result, the moderation system of subsidy takes a percentage of your subsidy to put towards environmental needs. But as a sweetener, if you can meet certain criteria, like proving you are using less chemicals and fertilisers, you can access more subsidy money via the moderation funds. This subsidy issue, combined with the national park, is leading French farmers toward organic production. Both Cyrille and Jean-Claude are dealing with its associated problems of weed control and plant nutrition.

We visited a farmer with Jean-Claude to discuss the results of trials, comparing the conventional and organic growing technology. It must be said at the start that some of the conventional cropping techniques in the Camargue use very high rates of chemicals (we heard cases of up to 10L/Ha of Ordram on barnyard grass). The organic trials were using techniques such as: winter flooding for weeds; sowing into and on top of soil; inter-row cultivation; sowing with precision seeder, however, the costing was not yet done.

ITALY

I visited Italy's Ente Natzionale Risi in Mortara and met with its Head of Research, plant breeder Dr. Massimo Biloni and Senior Agronomist, Dr. Moritsio Tabacchi. Italy is the EU's biggest producer of rice, with 220,000 hectares of production, compared to Spain with 110,000ha and France, Portugal and Greece all producing 20,000ha of rice. Production takes place predominantly in the Po River Valley, in the north of the country, with industry average yields of around six tonnes per hectare. Interestingly, Italy's rice consumption is 5kg per person per year and dropping. (It varies from zero per head in the south to 20kg per head in the north). As well as historical reasons for this difference, price plays a role. Subsidised rice sells for $2 - $3 per kilogram compared to pasta at $1 per kilogram. As we learnt at a later meeting at the European Union in Brussels, the fact that a lot of rice produced in the EU is not what the consumer wants and is being placed into stock piles does not help.

Dr. Biloni showed us through most of his breeding trials. A lot of his work is focussed on trying to breed varieties -'Long A' a long and slender grain, which attracts higher premiums - to suit the consumer demand. He is also working on Rice Blast resistance and cold sterility. One of the unfortunate findings of his research, so far, is that most of the cold tolerant varieties that he has been using in his trials are also highly susceptible to Blast. This highlights the importance of Blast screening trials (and also highlights Australia's need to maintain tight quarantine controls as we do not have Rice Blast and don't want it).

Dr. Biloni believes that biotechnology has many advantages, unfortunately, at the moment in Italy there are no GMO varieties registered, and research and testing are tightly controlled. He said this is because that they have had a succession of 'Green' Ministers who have been anti GM research. He said that the new Minister is letting some public work happen, but the politics is proving very difficult. This, he believes, is leading to the view in the wider community that GMOs are unacceptable. Dr. Biloni believes that they have done most of what can be done with conventional breeding.

Most of the Italian rice research is funded by the growers. There is some government funding for specific projects. The government likes European-wide type projects and there has been some work done on a germ plasm bank for the EU and also a small amount of GM work on Blast resistance. The levy on Italian rice growers for R & D is equivalent to about $6 Australian per tonne on a 1.3 million tonne crop. That levy is set by a board made up of twenty six people, ten farmers, ten millers, two traders, two from the co-operative and two workers.

Dr. Biloni and his team are participating in a worldwide experiment evaluating different varieties from around the world in the same set of trials. The Australian varieties: YRL101, YRL115 and YRL38 are included in these trials. Unfortunately, most of the Australian varieties included look to be susceptible to Blast. Most of the varieties that have been found to be resistant to Blast seem to have lower yields. Dr. Biloni speculates that they must expend more energy fighting off the Blast and as a result, cause lower yields.

A lot of research is also going on into the chemistry of grain quality. Risotto types, important to the local market, must be a big bold grain capable of being parboiled for the restaurant trade, whereas the export trade is looking more at long and slender, low amylose grains.

As we learnt at the EU, in Brussels, efforts are being made to reduce direct support on production and focus support more towards environmentally sustainable farming. Although this change looks to be very slow in coming, Dr. Biloni predicted that farmers would try and adapt their farming practices to differing incentive payments. Some had tried already to produce organic rice, with very mixed results. The major problems were weeds, in particular red rice and that the price premium was not high enough. Dr. Biloni saw part of the solution was to better educate growers to understand rice plant and weed physiologies to help manage these changes.

Dr. Maritsio Tabacchi took me through his agronomy and plant protection work. Similar to most places around the world, weeds were seen as one of the biggest agronomic yield constraints. Barnyard grass and red rice were the major problems. 70% of the rice area in Italy has red rice infestations. Some work is being done on controlling it in rotation with Soya beans and corn, they have also tried the US method of false flood, to pre-germinate the red rice, then spray or cultivate it out. As a last resort, they have tried wick wiping red rice prior to flowering. But Dr. Tabacchi sees the fact that certified seed can legally have up to 5 red rice seeds per 500 grams as a major hurdle to bringing red rice under control. With barnyard grass, they are currently using DNA markers to identify different types, so that they can be more specific with appropriate chemical applications, providing specific advice to farmers on what, how and when to use them on barnyard grass. He believes vigilance and education can help slow the spread of new weeds and herbicide resistance. One major problem for weed control is that no chemicals whatsoever can be applied aerially to rice in Italy.

Because of air pollution constraints and the fact that a lot of rice is grown on continual rotations, most stubble is ploughed under. This does not appear to be causing any major problems, except on heavy clay soils, where limited burning is allowed. Dr. Tabacchi is also

looking at the need to improve nitrogen use efficiency. Normal rates range from 120 – 150kg of N per hectare. This is split over pre-flood and two or three and sometimes up to four or five midseason applications. He is working with nitrofication inhibitors to try to cut total use by 15 to 20% or one to two applications. This is a similar problem to that occurring in Japan. Dr. Tabacchi is using Ca CN2 as his inhibitor. There is also a new inhibitor 3-4DMPP, which can be sprayed onto ammonium sulphate or urea.

SOUTHERN USA: Louisiana, Texas, Mississippi, Arkansas.

Dr. Rouse Caffey, Chancellor and Professor of Agronomy Emeritus of Louisiana State University (LSU), helped organise a number of meetings at LSU and many other rice related research facilities throughout the southern US rice growing states for fellow Nuffield Scholar, Russell Ford and myself. Dr. Caffey had only recently stepped down as Chancellor and was able to give us a wonderful guide to the southern rice industry. He was also very impressed with the ideals of Nuffield that had sent practising farmers off around the world to study, and took great pride in introducing us as such. LSU is huge, 31000 students, with programmes in everything from rice breeding to basketball (home to Shaquille O'Neill). It also has a very extensive budget, including generous corporate funds.

Because of its much more tropical climate, the rice programmes in the southern US have a different focus to our own, but we found that there were many issues that had lessons for us. Dr. Jim Oard, LSU's rice specialist, gave us an overview of their rice research programme, in particular, disease and weed resistance work. They are taking two approaches to most issues: traditional and biotech. Red rice is the major weed problem for the south. One of the main issues with red rice control is that it easily outcrosses. LSU is working in the area with commercial partners like Cyngenta.

The political and consumer climate in the USA is much more pro-GMO production than in Australia and in particular Europe. This has produced a much stronger focus by US scientists and breeders on looking at biotech solutions. It also means that they have had to seriously address problems like outcrossing of transgenic lines. With red rice's close genetic relationship to cultivated rice, the issue of outcrossing and its management is vitally important. Transgenic rice and rice with naturally occurring resistances, like Clearfield (IMMI rice – conventionally bred rice selected with a naturally resistance to the Immidazolon chemicals), must be managed carefully after release to give the system a better degree of longevity. They are working on rotational systems of chemical and paddock management to avoid outcrossing and resistance, similar to that which is commonly recommended practice in Australian rice industry.

Also on the weed control agenda at LSU, Dr. Eric Webster spoke of his work on trials with chemical impregnation of fertiliser. The basic philosophy of this work is to help cut production costs by lowering the number of passes of the rice field each season and also to get around the problems of chemical application to flooded rice fields, by reducing the risk of off-target damage, which is leading to tougher and tighter regulations on chemicals and their application. So far, the results have been very promising on grass weeds using Clomosozone (commonly used in Australia) impregnated fertilisers and they now plan to do the same work with Londax (also widely used in Australia) for aquatic broadleaf weeds. He is also running trials on chemicals to do salvage control on barn yard grass, which would be useful in the Australian context. They are currently showing promising results with Regiment and Clincher.

These talks led to an interesting discussion on the cost and time involved in registering new agricultural chemicals. Often, the same set of tests has to be carried out in different countries and even different State jurisdictions to meet regulatory requirements. Taking into account the need at times for some specific localised testing, it seemed to us that a more standardised form of chemical registration could help reduce costs and speed up the process. This is an area that I feel should be looked at in a broader research and development context.

CALIFORNIA

The Californian rice industry is the one I found to have the most similarities to Australia, in climate, growing techniques, varieties and yields. California currently produces approximately two million tonnes of rice from 227000Ha, with an average yield of approximately nine tonnes per hectare, the vast majority of which is medium grain (205000Ha). Most of California's rice appears to be grown as a monoculture, very little rotation with other crops takes place. Rice growers are rice growers. This is leading to some major weed control problems, which are not helped by very strict EPA regulations on chemical use, both in type and application methods. Stubble handling issues in rice on rice production are also a growing problem due to the reduction in stubble burning being forced upon growers by pressures coming from urban encroachment into farming areas. Two new problems in the last couple of years have been the discovery of both Rice Blast and Bakanae disease.

California's major research facility is the Biggs Research Station. The rice industry also has a close association with the University of California, Davis Campus (UC, Davis). The Biggs Station is the home of the California Cooperative Rice Research Foundation (CCRRF), which

is owned by growers and operates under a board of growers. I visited both Biggs and UC, Davis to look particularly at what was happening in their breeding programmes. Carl Wick, a retired County Agent (District Agronomist), was my tour guide. At Biggs I met Dr. Kent McKenzie, the Director and Senior Plant Breeder. The main areas of focus at Biggs are seedling vigour, cold tolerance, early maturity, short stature, pest resistance, grain quality and type. This last area of grain type has seen renewed focus on producing high quality long grains to lessen California's reliance on medium grain markets.

The key characteristics they are looking for in long grain breeding are milling and cooking quality. They are investigating new screening procedures to help speed up and refine improvements, including amylose, gel temperature and cooking samples, as well as the usual physical measurements. They are also working on a special quality rice, with two to three percent higher amylose, which is ideal for parboiling and noodles because of its dry cooking characteristics. The variety, L205 (Newrex), appears to be performing well in trials. Short stature traits are important to maintain and improve as it cuts back stubble volumes, which helps one of California's big rice production problems, the phasing out of stubble burning.

The Californians have successfully introduced stem rot resistant genes into new breeding lines. They have also introduced rice water weevil tolerant genes and have just initiated a resistance-breeding programme for Rice Blast, to help counter this recently introduced disease.

Bakanae disease was first discovered in California in 1999. It is a fungus disease that attacks the plant about twenty-five to thirty days after sowing. Most plants affected die two to three weeks later. It may continue to affect more plants, as the crop gets older. It appears that it may spread via seed contamination with the spores of the fungus. Fallowing of paddocks may reduce the effectiveness of the fungus. Work is being done on both detection in the field and understanding in the laboratory. Some preliminary tests have been done on using a chlorine seed treatment to help reduce contamination. Like Rice Blast, hopefully quarantine can keep Australia free of Bakanae disease.

TEXAS

I visited the Beaufort Texas Rice Research Station, which is run by the Texas Rice Improvement Association (TRIA), who works in close collaboration with the United States Dept of Agriculture (USDA) and the State University. Because most of the Texas rice industry is located in the more heavily populated areas along the Gulf of Mexico, it is gradually shrinking in size due to urban encroachment and its need for water. Dr. Shannon

Pinson, the Head Research Geneticist at TRIA, painted a pretty gloomy picture for the future of rice production in Texas. She saw the need to maintain an agricultural base and way of thinking as important and saw an opportunity to look at highlighting the current water uses environmental benefits. But she admitted at this stage they had all the questions but no answers. One of the main structural problems that Dr. Pinson again highlighted was that up to 80% of rice grown in Texas and neighbouring Louisiana is grown on rented land. This has had a very detrimental effect on rice producers via rules within the Farm Bill, which see the absentee land-owners receive most of the payments. In many cases, this is having a very negative affect on long term land and water management issues.

One of the bright notes of rice production in Texas is the work being done on rice Hybrids by the private company RICTEC Inc. The Australian rice industry has followed the development of Hybrid rice with interest. China is currently the world leader in Hybrid rice technology and production, but up to this point, the Australian rice industry has made a conscious decision to stay out of Hybrid rice production. I was fortunate enough to be able to visit one of RICTEC's farm trials during harvest and talk with one of their technical representatives, Jeffrey Mosley. RICTEC has made solid progress over the last few years, with Hybrids continuing to increase as a percentage of Texas' total plantings.

The main benefits of Hybrid production in rice at this point seem to be yield increases. In Texas, at the moment, Hybrid yields are on average 15 – 20% higher than normal. Another striking feature is the low seeding rate of approximately 35kg per hectare, which is less than 50% of the normal seeding rate. It also is achieving these yield gains using 60 – 120 units of nitrogen compared to the normal 180 units. Disease resistance in the current RICTEC varieties seems to be quite good. All these things make Hybrid rice look very attractive to the grower, but several problems still exist, including increased susceptibility to straight head and some sensitivities to commonly used molinate herbicides.

The biggest downside to Hybrid production currently lies in the area of grain quality. Milling yields are down at least 10% on most common varieties. If this issue of grain quality in Hybrids can be addressed, and providing that seed cost can be kept competitive, the yield advantages would seem enticing on two fronts, both dollar return and tonnes produced per megalitre. My guess is that the time is fast approaching for the Australian rice industry to at least take another close look at the pros and cons of Hybrid production.

5. Water Use Efficiency

Most rice growing regions that I visited are just starting to look at rice production through the eyes of water use efficiency. Water, in most cases, has not been seen as a production-limiting factor. Most rice programmes have focussed on higher yields per unit of land, but are now seriously looking at yield per unit of water. This approach needs to start with accurate measurement of water during the growing season; measurements such as rainfall, evaporation, water onto crop and drainage. Most of the systems that I looked at were very disappointing in this regard. Areas with gravity-supplied and metered water were generally better measured than pumpers, both river and subsurface, but there was almost no measurement of drainage runoff in any system.

Because of rice's pondered water growing technique, it is often targeted as an inefficient user of water. Pressure to improve water use efficiency in rice growing is coming from many external forces, such as urban development, competing agricultural and industrial uses and environmental demands. Water use efficiency can be measured in many ways: hectares grown per megalitre, tonnes per megalitre, finished product per megalitre, dollars per megalitre, even meals per megalitre.

Though most of the countries that I visited lacked good measurement systems for on-farm water use efficiency, work is starting to progress. Even without accurate measurements gains can be made in on-farm areas through things like laser land levelling, improved supply drainage and recycling systems, soil suitability criteria, bay and outlet design and rotational cropping programmes.

In Italy, I visited the Est Sesia Irrigation Association Head Office in Novara and met with Director, Franca Franzoni. The Est Sesia Irrigation Association is responsible for the supplyof water for approximately half of Italy's rice production. It utilises water from the Po River and Canale Cavour. The water originates in the Alps from glaciers and snow melt and is delivered through a canal system, parts of which were designed by monks as far back as the 11^{th} and 12^{th} centuries. Under this system of water delivery, water is delivered to the largest farm in an area and then is allowed to pass through those fields to those of smaller surrounding farms, or the small farmers work in district groups with one point of delivery from the main canal, passing water down from field to field. This system has developed over time due to the fact that Est Sesia supplies water to 100,000Ha of rice over a total area of 210,000Ha, a vastly higher rate of irrigation intensity than we are used to in Australia. The larger farmers are charged for the water at a rate of Lire per constant flow rate onto farm, whereas, because of the difficulties with measurement of what is passed down to them, the

smaller farmers pay by area of crop grown. Most drainage water is captured back into the canal system, but some does find its way into the river.

Although abundant water supplies have meant that on-farm water use efficiency has not been the highest priority for Italian rice growers, growing environmental and financial constraints mean that the issue now has to be addressed. Est Sesia is currently looking at better water measurement techniques such as ultrasonic flow meters in canals.

Another area of on-farm improvement of water use efficiency is in the use of rotational crops after rice, to better utilise the residual moisture for both a better net return to the farmer and also to stop the unwanted movement of any unused rice water in the soil profile. Projects are underway looking at this, in Italy, IRRI and some of the Southern US States.

Another potential area of water use efficiency came up during discussions and that is can precision agriculture help us to better understand and control water use? It is an area I have not spent any time on, but which I believe needs to be followed up in the future, as I know many groups are investing a lot of time and effort into precision agriculture already.

6. Water Politics

Studying the politics of water created many of the most interesting and memorable discussions of my trip. The current political and legislative debate around water in Australia at this time, made me think that it would fit comfortably and yet somewhat provocatively with my other tour goals. In Australia, at the moment, who doesn't have an opinion on water.

Despite appearances, California's water system operates as one giant interconnected system, moving water from east to west and north to south. Developed in the mid-twentieth century, it is the life-blood of California, both physically and economically. The Californian system of water use within its river valleys has traditionally seen large volumes of water available at lower prices in the upper reaches and progressively smaller volumes and higher prices as you move down the valley. This evolution is now being dramatically reversed by the demands of massive urban growth in cities at the bottom of the system. Legally, the basis of California water rights is First in Time, First in Right (Lance W. Johnson P.E. –The Water Group).

California's challenge is to balance the needs of its massive irrigation based agricultural economy with the fast growing population needs of cities like Los Angeles, San Diego and San Francisco that are already facing serious water shortages. I spoke on these problems with one of California's leading experts on the water debate, Lance W. Johnson of The Water Group, a water resources service organisation. Lance's explanation of the major players of the Californian water debate had a very similar sound to the situation in Australia. The four key players are: environmental interests; agricultural interest; urban water interests and resource agencies acting on behalf of strong environmentally focussed laws. Like Australia, the responsibility for water in the USA traditionally lay with the States, but the past decade has seen much of the control over water passed to the federal government via strong environmental protection legislation. California's water sharing problems were exacerbated by one in two hundred to four hundred year drought between 1986 and 1992, which highlighted environmental concerns and water shortages for the San Francisco Bay delta. The 1994 Delta Accord and the following CalFed Bay-Delta Program saw significant water given back to the environment, but Lance believes that this has failed to achieve any real outcomes because the science behind the decision-making is poor to non-existent.

Added to the environmental problems, is California's rapid population growth, from the present 32 million to an estimated 50 million by 2020. It is Lance's view that the urban areas will get the water, it is just a question of how. In some areas the water is simply taken by changing the land use from irrigation to housing. For the bigger urban areas, it seems the solutions area either to purchase or to legislate (some farmers have already decided to sell,

hence the new term 'Cadillac Deserts'). I very much got the impression that farmers, as individuals or groups, felt that they had very little or no input or control over these changing circumstances. One of the views commonly put was that their time was better spent lobbying for support via the Farm Bill (subsidy in its many forms). As has happened in Australia, water trade is being put forward as some as a solution, but Lance and most others I spoke to believe that this will not be so for agriculture because as the volumes get smaller the price gets higher and agriculture is forced out of the market.

I left California with a gloomy view of irrigated agriculture's future from most of those involved. But on reflection, perhaps the gloom was overstated. Water drives California, and although it has problems, the facts are the balance of water use is always changing and I am reminded of Darwin's saying that it is not the biggest nor strongest or fittest, but those which best adapt to change that will survive.

The drivers of water politics in Italy differ to those of other countries that I visited. First and foremost is that no one I spoke to talked of any sort of water shortage in Italy. Franca Franzoni, at the Est Sesia Irrigation Association sees the main competitor to agriculture for water as being the hydro-electric industry, with other pressure coming from industrial and urban users and green groups. Water quantities are such that volume does not seem to be a limiting factor, as yet, in Italian rice production. The issues of timing of delivery(hydro-electricity) and water quality seem more pressing.

The Greens in Italy, for instance, are against the EU subsidy system of set aside for rice (payment to farmers to take land out of production) because of the changes it may cause to the current ecosystems that support wildlife particularly water birds. But on the other side, they are pushing for tighter controls and regulations on fertiliser and chemical use.

One of the other major issues for Italian irrigators is the role that the irrigation schemes play in the important role of flood mitigation. Much has been written of Venice's continuing problems in controlling water levels, but many other cities can also be affected and part of the design of the irrigation schemes is such that they can mitigate against major natural disasters.

One observation I made during my tour was that the building of new water storage systems seems to be off the agenda in all but the newly developing countries. I believe that growing populations and their demands for food and water will force many countries, including Australia, to take a fresh look at this possibility in the medium to long term. It will cause an even bigger debate than the one we are having currently over existing water use. The challenge for is to take lessons learnt in this present debate forward and come with some fresh and innovative plans for the future.

7. Other Learning

On such an extensive tour that the Nuffield experience offers, it is impossible not to learn many things beyond the actual area of study. It would be remiss of me not to mention some of these in this report. The following is a summary of some of the interesting issues raised around the world.

Egypt

As mentioned earlier, I had planned to visit Egypt as one of the key components of my study. Egypt has many similar issues with rice production as we in Australia have; similar climate, lack of water and increasing salinity problems. Due to the events of 11th September, I reluctantly, decided against this visit and had hoped at some later stage to complete my study there, but unfortunately, to date, this has not proved possible.

I spoke at length to Italian plant breeder, Dr. Massimo Biloni, about the Egyptian rice industry. He has close contact with Egypt's 'Mr. Rice', Dr. Tantawi Badawi, and was very disappointed for me that I had had to cancel that part of my trip. He explained some of the work going on there. In particular, he explained about Dr. Badawi's five year programme on Hybrid rice, looking at its role in stressed environments, particularly, salt and drought, and with lower inputs. The Hybrid was already outperforming conventional varieties in salted environments. We also discussed Dr. Badawi's water use efficiency project. He has studied irrigation withholding periods at each stage of growth and their effects on yield versus water use to establish critical points of water management. He is also investigating alternate irrigation intervals, looking at increasing time patterns between irrigations and their corresponding effects on yield versus water use. Also included in the project are things like plant density and its role in water use via evapotranspiration, even transplanting versus direct seeding.

Further reading on this research shows that Dr. Badawi reached the following conclusions on ways of increasing water use efficiency in Egyptian rice fields: using short duration varieties instead of long; using the optimum plant variety for each specific role; encourage farmers to utilise laser land levelling techniques; use of new drought tolerant varieties; improving irrigation and drainage systems to minimise losses; develop public awareness of the importance of water and methods of saving; and withholding irrigation water for a short time at the medium tillering stage and during the late grain filling stage.

Ontario Environmental Farm Plan

During our time hosted by the Canadian Nuffield Organisation, we were shown many interesting facets of Canadian agriculture. One that struck a particularly strong cord with me was the Ontario Environmental Farm Plan, an extremely user-friendly step-by-step management plan, in which farmers are able to progressively involve themselves. In Australia, we seem to be developing a myriad of unrelated and unconnected 'plans'. The Ontario model appears to set some good examples of a more workable and productive set of guidelines. We have already taken some ideas from this as a starting point to building a rice environmental programme.

US and EU Subsidies

One of the major reoccurring topics of the tour was agricultural subsidies. We were given many different viewpoints on these in both North America and Europe. The bottom line appeared to me that subsidies are here to stay for the foreseeable future. We were in Washington during negotiations on the latest round of the Farm Bill and the most common topic of discussion was the fact that both sides of politics were lobbying for more money to go into the programme. On figures that we were able to glean, the average US rice farmer was receiving about sixty percent of his income via several different forms of subsidy. This has caused some interesting and unforeseen side effects: like the inflation of land values and the consequent problems of land ownership, for example, in Arkansas and Louisiana around fifty percent of rice farmers are tenet farmers, some on quite short term leases. This is creating problems with long term land management and environmental issues.

The EU subsidy debate is at least starting to talk in terms of environmental management rather than simply subsidised production. Discussions we had in Brussels still highlighted the ultimate dependence of many EU farmers on subsidies to survive. The EU subsidy issue seemed to me to be more related to keeping farming communities in place than just simply encouraging production. Nowhere in the debate on either continent did we get to run out onto the much vaunted 'level playing field'.

Third World: Asia, Mozambique

This trip provided me, for the first time, with a first hand view of some of the most basic issues in Third World countries. Visits to Indonesia, The Philippines and Mozambique highlighted the simple needs of many of the world's population. As over half the world's population survives daily on rice, the research being carried out by the rice industries around the world can serve a vital role in alleviating hunger. It seemed to me almost unbelievable that countries like Mozambique with wonderful natural resources can't manage to feed itself. We can help with the science and technology, but I am not sure who sorts out the politics and ideology.

Human Resource Exchange Programme

One of the outcomes already from my Nuffield tour is that I have initiated a human resources subcommittee within our rice R & D programme. The point of this is to help encourage participation from our industry in programmes like Nuffield, ARLP, Women in Agriculture etc. I also believe that this can be extended to look at further exchange programmes amongst the rice industries in various countries. It is important that we nurture and develop our most important resource, people.

Environmental Partnerships

Challenging times particularly in relationship to irrigation practices and access to water highlight the need to work in partnership with all sections of the debate. On this trip I saw several successful partnerships that had developed from opposite ends of a spectrum to solve a common problem. In California, rice farmers, environmentalists and hunters are working together through a group called "Ducks Unlimited". The environmentalists want to see water bird habitat revitalised, the rice farmers are no longer able to burn stubble and so are reflooding their fields in the winter (the natural timing for the ducks to be there) and the ducks are helping to incorporate the stubbles into the mud and are also feeding on the weed seeds. The hunters then have controlled access to much increased bird numbers. The farmers also benefit economically from the hunting. Everybody has gained, even the ducks (though not the slow ones!).

Research and Development

Research and development programmes that I visited are managed and funded in many different ways. As a general rule, the most successful programmes are either grower managed or have strong grower input. Further I believe, using grower funding certainly helps to concentrate research efforts. It is nice to receive lots of outside funding, but sometimes this comes with ties or can result in a loss of focus.

Registering Chemicals

A discussion point on many occasions during my trip was the time and expense involved in registering agricultural chemicals. It seems to me that much effort in this area is needlessly duplicated and perhaps through groups like Australian Government's National Registration Authority (NRA), the idea of a simpler and more transferable system of registration can be looked at.

Quarantine Issues: Blast, red rice (Arkansas, Louisiana, France, Italy)

The prevalence of many diseases and weeds of rice that I encountered during my tour only served to highlight to me the importance of quarantine. Australia's rice industry has very few competitive advantages in the world market. Our cost of production is helped by the fact that we do not have diseases, in particular rice blast, and to this point we are also free of the difficult and costly to deal with weed red rice.

We currently have a rice exclusion zone in our rice growing areas of southern New South Wales and northern Victoria, as well as the normal national quarantine rules and restrictions. I believe, as an industry, we need to maintain our vigilance in this area.

8. Conclusion

The original aims of my Nuffield study tour were the search for new ideas in the areas of plant breeding and technology, water use efficiency and water politics, to help address two of the Australian rice industries major production limiting factors; reproductive cold sterility and water availability. As well as my findings in these areas, along the journey I picked up a number of other facts on issues of importance to my own farming practices and the wider Australian farming community.

In the area of plant breeding and technology, it is my belief that the developing genetic technology is well on the way to offering the tools capable of progressively improving tolerance to cold sterility at the rice reproductive stage. The completion of the world-wide effort in mapping the rice genome and the work currently being done to understand these gene functions is already providing solutions in areas such as grain quality (marker aided selection) and, from what I have seen and heard during my study, is bringing us much closer to reducing cold damage. Two important observations in this area are: one, that whatever genetic tools, or building blocks, are provided, the role of the traditional plant breeder will still be of the utmost importance to the integration into suitable local cultivars and for the development of protocols for their management in localised production systems. Secondly, the issue of consumer perceptions with biotechnology needs to be understood and addressed. The Australian rice industry, like several others I visited around the world, currently has a moratorium on GM production. But perceptions can and do change, and I believe that biotechnology provides such positive tools that it can't be ignored and that real efforts need to be put into highlighting its environmental, consumer and production benefits.

Water use efficiency provided the only minor disappointment of my Nuffield study in that most of the countries visited lag well behind Australia in acknowledging and dealing with water use efficiency in rice production, particularly on farm. Most countries have previously concentrated on lifting production per hectare, not per unit of water. But now, in many cases, increasing urban and industrial growth, environmental needs and competing forms of agricultural production are forcing rice industries to put serious effort into addressing water use efficiencies. California is the most obvious exception to this, but even there they are still behind our on farm systems in areas of measurement and soil suitability criteria (I could see an export opportunity with our developing EM31 and soil sodicity technology). Most of the improvement in water use efficiency in the programmes that I visited was based on a focus around breeding issues, things like continuing improvement of shorter growing season

varieties, and introduction through both traditional and genetic methods of solutions to cold and drought stress, all of which would cut water use while offering stabilised levels of higher production.

As for the politics of water, my travels lead me to the conclusion that water will continue to move from agriculture production to urban, industrial and environmental uses. This is happening in some areas via economic means – trading in licences and access – and also through government legislation and even through the court system.

I think it is important that I finish this report by highlighting the interaction between the three areas I studied. One area alone will not be able to solve all problems. We need to continue producing better plant breeding and production technology, but we must also maintain a focus on continual on-farm improvement. And we must continue to provide a strong and innovative voice in the politics of water.

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10. Quotes of Interest

On the study tour I met many interesting and knowledgeable people, who had some interesting points to make. The following are some of the things said.

Dr. Len Wade – IRRI

"The distribution to solve the hunger argument is bullshit"

The real issue is local production, getting knowledge to farmers.

Dr. John Sheedy – IRRI

"Climate change is real"

Expected temperature rise this century is up 6%.

Dr. G. S. Khush – IRRI

"I have no doubts that science can feed the world."

Dr. Massimo Biloni – Ente Natzionale Rizi

"It is more difficult to tell people to go than to stop"

Dr. John Robinson – Rice Research Extension Centre, Stuttgart, Arkansas

"The face of the prairie will change!"

Water is now the key issue.