The Winston Churchill Memorial Trust of Australia

Report by Loretta Serafin

2006 Churchill Fellow

The SWIRE GROUP Fellowship to study:
Alternative summer oilseeds for profitable, sustainable crop rotations in North Eastern Australia.
Investigation of factors affecting yield, oil content & quality to allow greater economic returns and alternative end uses to enable value adding for farmers.
Specifically:
1. Sunflowers- A small industry in the midst of a significant resurgence requiring greater agronomic and value adding support.
2. Sesame- A potential new industry, suited to the drier areas of northwest New South Wales and southern Queensland, requiring further adaptation and agronomic information.

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Signed: Date:

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1 Introduction

This fellowship enabled me to travel to Italy, France and the United States in order to study alternative summer oilseed crops; primarily sunflower and sesame.

I wish to extend my appreciation to the Churchill Trust for providing such a unique opportunity for Australians such as myself to experience and develop knowledge and understanding of industries in a range of overseas environments.

I also wish to acknowledge and thank the Swire Group for their invaluable support of this fellowship. Their commitment to Australian agriculture is an invaluable contribution to several significant rural industries.

Support of the NSW Department Of Primary Industries, as my employer is also acknowledged. I am thankful for the support of my fellowship and this opportunity to experience international agriculture for the benefit of farmers in NSW and Australia and myself.

The Fellowship programme would not have been as rewarding without the support and interest of all the people whom I met overseas. I would like to extend my personal thanks to them all.

However several people went to considerable additional effort to assist me during this process. I thank them very much and wish to acknowledge their support as such:

- Dr Phillip & Mrs Linda Stahlman, Kansas State University, Hays, Kansas, USA
- Mr. Ray Langham & Mr Terry Weimers, Sesaco, Texas, USA
- Professor Gian Paolo Vannozzi, Udine University, Italy.
- Dr. Tom. Gulya, United States Department of Agriculture, Fargo, USA.

Thank you also to my husband Michael, who supported my application and accompanied me on my travels.

2 Executive Summary

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The fellowship was undertaken between the 7th September and the 31st October 2006. The aim of the fellowship was to visit researchers, companies and farmers where alternative summer oilseed crops (namely sunflower and sesame) are grown, commercially harvested, processed and sold.

I visited a range of universities, agricultural departments, private companies and farmers to view their role in the value chain leading to the production of these crops.

I was also fortunate to participate in the International Symposium on Sunflower Industrial Uses in Udine Italy, where participants from the world sunflower industry were present.

3 Highlights

- Participating in the international First Symposium on Sunflower Industrial Uses in Udine, Italy
- Visiting Thierry Guerin, a farmer at Thionville, near Paris, France
- Touring Red River Commodities, sunflower processing and packaging plant in Fargo, North Dakota
- Meeting with Ray Langham, Sesaco in Texas and visiting local sesame farmers.
- Visiting two ethanol plants, a gluten plant and a flour mill near Oakely and Russell in Kansas.
- Visiting with researchers and farmers in Hays, Kansas including weed scientist Dr. Phillip Stahlman, Kansas State University and presenting to the weeds group at Manhattan campus.

4 Implementation and Dissemination

- The knowledge gained will be disseminated to farmers in northeast Australia through various media and my daily interactions with farmers in my role as a district agronomist.
- Through public presentations to farmer meetings and other interested groups.
- Various written media releases in regional media.
- Completion of two interviews with ABC radio
- Presentations to the Tamworth West Rotary Group and the Tamworth Produce Marketing Co-operative
- Development of further sesame evaluation and sunflower trials on farm.
- Collaborative work with international scientists. Currently it is hoped an American weed scientist will come to work in Northern NSW in 2007. Hopefully this will be the start of similar exchange programs for researchers and farmers.

5 Fellowship Programme

EUROPE

11- 14th September - Udine, Italy

- First International Symposium on Sunflower Industrial Uses, Udine Italy. September 11-13th , 2006
- Udine University Farm – Biodiesel Field day
- Sebastien Chatre – RAGT Sunflower breeder, near Toulouse

25-29th September - Paris, Clermont-Ferrand, Toulouse and Thionville, France.

- Raymond Reau, Scientific Director ,CETIOM
- Anne Maree Triboi, Agronomist & Felicity Vear, Sunflower Breeder, INRA, Clermont Ferrand
- Philippe Debaeke, Research Officer, INRA Toulouse
- Farm Visit with Thierry & Valerie Guerin, Farmers, Thionville

THE UNITED STATES OF AMERICA

2nd – 7th October – Fargo & Mandan, North Dakota

- Red River Commodities Inc – Todd Mondry
- Joe Krupinsky, Plant Pathologist, Don Tanaka, Soil Scientist & John Henderson, Pastures Researcher, Northern Great Plains Research Laboratory, USDA, Mandan.
- Burton Johnson, Special crops agronomist, NDSU, Fargo.
- Tom Gulya, Plant Pathologist, USDA, Fargo.

8 – 14th October - Hays, Colby, Russell, Manhattan in Kansas & Columbia, Missouri

- Steve McNinsch, Ethanol Plant, Colby, Kansas
- Rob Aitken, Crop Scientist, Northwest Research-Extension Centre, Colby, Kansas State University (KSU)
- Keith Harmoney, Pastures & Rangelands Scientist, Agricultural Research Centre – Hays, KSU
- Lance Russell, Farmer, Hays, Kansas
- Greg Kerr, USDA Farm Service Agency, Hays, Federal agricultural agency.
- Ron Dunbar and Regis Weiss, US Energy Partners - Russell
- Dave Reisig, Farmer and Certified Seed producer & Seller, Russell
- Phillip Stahlman, Weeds Scientist, Agricultural Research Centre – Hays, KSU
- Presentation to Kansas State University Weeds Group at Manhattan campus
- Michael Stamm, Canola Breeder, Manhattan, Kansas State University
- Rob Myers & Mike Bachman, Jefferson Institute, Columbia, Missouri.

15th – 21st October - Lubbock, San Angelo and San Antonio, Texas

- Calvin Trostle, Extension Officer, Lubbock, Texas A & M University
- Peter Dotray, Weed Scientist, Lubbock Texas A & M University
- Steve Chapman, Farmer & President of the American Sesame Growers Assoc.
- Dr. Raymond Brigham, Retired Research Professor, Texas A & M
- Cliff Bingham, Organic Farmer, northwest of Brownfield, Texas.
- Billy Warrick, Extension Officer, San Angelo, Texas A & M University
- Ray Schwartz, Farmer & Vice president of American Sesame Growers Assoc.
- Ray Langham, Sesaco & Secretary/Treasurer of American Sesame Growers Assoc. & Terry Weimers, Sesaco
- Stephen Kaffka, University of California, Davis.

6 Sesame – A Potential Industry

Sesame, while an ancient crop, has struggled to be domesticated to a point where broad acre farming techniques can be used to grow and harvest the crop. While there are significant market demands from several Asian countries, much of the current sesame breeding and growth occurs in areas where many of the processes involved with crop growth such as planting, weed control, harvesting and processing are completed using manual labour.

Sesame as a crop has several major issues to contend with probably the best known of these is the ability to harvest the crop without significant losses. As a plant it is naturally dehiscent (sheds its seeds once they are ripe) and indeterminate, meaning seed at the bottom of the plant may be ripe at the same time as the plant is still producing flowers at the top.

Sowing the small seeds and establishing a productive stand are also important issues which need to be overcome in Australia.

Weed control in sesame also provides a significant challenge. Research into a range of suitable herbicides to selectively control broadleaf weeds is still continuing.

Sesaco, an American company, led in many ways by sesame breeder Ray Langham, is the one company in the world where the crop has been advanced to the point where the whole value chain is present and crop production is mechanised. Sesaco contracts farmers who with assistance from Sesaco grow the crop and carry out all necessary agronomic requirements such as fertiliser application, harvesting and delivery. Sesaco and its partner companies handle the receival and processing of the crop to produce the end products.

Photo No. 1 Loretta Serafin standing in a ripe crop of sesame near Uvalde, Texas, holding volunteer sesame plants which had started to regrow from lost seed.

6.1 Why consider sesame as a potential crop for Australia?

Currently there are several smaller companies who contract sesame growers and produce the crop within Australia. However the main breeding capacity has been carried out by Malcolm Bennett in the Northern Territory Department of Primary Industries & Fisheries.

Sesame offers valuable opportunities for our Australian farming systems:

- An alternative summer crop with rotational benefits, including a deep taproot.
- High value crop, with potential for increased returns for farmers.
- Drought tolerance (a major factor in our environment) enables the crop withstand considerable heat during critical growth stages.
- Alternative weed control options to reduce the risk of resistance of weeds to commonly used chemicals such as Atrazine® in sorghum.
- Opportunity for value adding and potential as an export crop.
- Few insect problems meaning few in-crop insecticides required.
- Low demand and need for high-cost nutrient inputs
- Sesame suppresses root-knot nematode and cotton root rot which is beneficial for the following crop.

6.2 Sesame Uses

Sesame is grown for its seeds, which are quite tiny. There is a variety of current uses for sesame including crushing for oil production, dehulled and dried or roasted products.

Sesame contains antioxidants and its oil has an excellent shelf life. Sesame is also used to produce tahini (a paste made from ground sesame). Historically it has also been made into a wine and used as a base for perfumes and for medicinal uses.

Sesame can also used in making margarines, soaps, paints and lubricants although this is rare currently. However it is used in making pharmaceuticals and cosmetics.

6.3 Sesame growing – Critical steps

6.3.1 Where to grow sesame

Sesame is quite an adaptable crop. It will grow on a range of soil types as witnessed in Texas, ranging from quite sandy soils through to the heavier clay soils often found in northern NSW Australia. On heavy clay soils raised beds are helpful if waterlogging occurs.

As a drought tolerant crop it is being grown throughout Texas including some of the drier areas in the West.

Sesame is also successfully grown under irrigation and various methods of irrigation, including centre pivots and furrow are suitable.

6.3.2 Crop Establishment

Good crop establishment is critical as a low or uneven plant stand (as with most crops) will lead to reduced potential yield and increased variability in the maturity of plants in the paddock. Plants in low population areas will compensate by altering their canopy architecture to create more branching, however this may lead to uneven maturity across the field.

Soil temperatures that favour rapid emergence and establishment have been studied by Ray Langham and found to achieve the best results at or above 21 deg C (70 deg F).

Sesame is a very small seed, meaning seed depth placement and the environment for emergence of the seedling are very important. Farmers in Texas advised that the seed should not be planted more than 2.5cm below the soil surface and covered with loose, friable soil.

Crusting of the soil surface is another important issue which can inhibit emergence. Crusting may occur through two situations, firstly when rain falls after planting but prior to emergence and secondly specific soil types such as the sandy loam soils of west Texas and parts of southwest Oklahoma which naturally crust if the soil is wet and becomes compacted over the line of seed during planting.

In order to overcome problems with crusting soils farmers use a variety of methods including a light set of finger harrows behind the planter or sometimes a pass with a light set of harrows a couple of days after planting (whilst being careful not to disturb emerging seeds). However it is critical to check that the seed is not trapped in the crust before using harrows as this will unearth the seed and leave it exposed to drying out. The seed must be underneath the crust to use harrows successfully.

The current philosophy is that a group of seedlings have more “push” to emerge through crusted soil than a single seedling. As such several seeds are planted together, this is called “hill” planting.

The addition of a small amount of water to the seed bed, similar to the water injection of inoculants used with pulse crops is also used occasionally by farmers to assist the imbibing seed. This ensures the seed does not dry out prior to emerging when soil moisture conditions at planting are already marginal.

Machinery to handle such small seeds is another issue. The majority of growers in the USA are using their row crop machinery, mainly John Deere Max Emerge planters, equipped with sorghum plates in which holes are large enough to allow between 5-8 sesame seeds to pass through. Sesaco has encouraged the use of any available machinery to aid adoption of the crop into the farming system. Some farmers have used sugar beet plates successfully; however, they are not as common as sorghum plates.

It is essential with these planters to ensure that all gaskets and plates are tightly fitting as small sesame seed will run out of any little hole or gap.

Photo No. 2 A John Deere Max Emerge planter, showing the use of sorghum plates, where several sesame seeds fit into each hole. Tightening of the plates close fit to the outer gasket is critical to prevent loss of seed.

Growers also advised not to fill seed boxes more than 1/3 full as the additional weight of a full box of sesame seed will cause grinding and damage to the seed in the lower part of the box.

Another successful alternative machinery option is to use seeders commonly used for sowing winter cereals with holes blocked off to create wider row spacings than is common for wheat or barley.

It is recommended to pre-irrigate fields or plant after a rain event. This minimises the risk of a failed establishment from heavy rain or irrigation event covering in furrows, and burying the seed too deep for successful emergence or risking waterlogging and death of the young seedling.

Many planters are equipped with mechanisms to remove dry soil from in front of the planter. Some farmers have devised delvers (metal plates) fitted at the front of the planter to move a little dry soil away from the seed furrow during planting but several other different models are used.

While row spacings in Australia have tended to be somewhat narrow, around 30-40cm, the most common row spacings are between 75cm and 100m in Texas. Sesaco recommends their growers use 50-100cm row spacings. Narrower rows are used in irrigation or high rainfall areas and wider rows or twin rows (similar to single skip) are used in drier areas.

Row spacing is the USA is often more dictated by the type of sowing machinery available to the farmer, meaning there is often quite a bit of variation in row spacing depending on the other crops grown in the individual farm.

Farmers advised driving slowly when planting to also reduce bounce and uneven seed depth placement.

Press wheels are used to improve seed contact with soil moisture but care is needed not to apply excessive pressure and not to create too deep of a furrow, in case heavy rains follow planting.

Planting rates are usually between 2.8 – 5kg/ha (2.5 -4.5lbs/ acre) on advice from Sesaco, however new growers are advised to sow heavier than lighter as the population will thin itself as some plants become more dominant.

6.3.3 Soil Fertility

Sesaco recommends fertilising using nitrogen, in the order of

Dryland under 28” or 700mm annual rain	25-35 units of N
Dryland over 27” or 675mm annual rain	30-60 units of N
Full Irrigation (12” or 300mm)	60-80 units of N
Semi – Irrigation (6-8” or 150-200mm)	40-60 units of N
Semi- Irrigation (2-4” or 50-100mm)	30-50 units of N

(Source: Sesaco, 2006 Grower’s pamphlet)

Sesaco also recommends split applications of nitrogen with only 10-20 units of nitrogen being applied pre-plant and the balance applied 3-4 weeks later.

In Australia the most likely scenario would be for sesame crops to be sown into a full soil moisture profile on a heavy clay soil plus hoping for a couple of inches of in-crop rainfall. This would equate to applications in the range of 60-80 units or less of nitrogen per ha.

Sesame is a deep rooted crop which can scavenge for nutrients; however Sesaco advises adding nitrogen, phosphorus and potassium where soil tests indicate a deficiency. Split applications of nitrogen are also recommended to prevent excessive vegetative growth.

As the likely growing regions in Australia are all dryland conditions of less than 700 mm of annual rain or in areas using irrigation, this makes sesame a reasonably low nutrient input requirement crop when compared with sorghum where crop nitrogen applications are in the order of 100-150 units/ha on average.

As costs for Nitrogen continue to increase in Australia, a crop which has a low nitrogen requirement will aid in decreasing costs to the farmer. However it is recognised that nitrogen is only one cost to a farmer.

6.3.4 Insects

Once established, sesame is able to withstand quite hot temperatures and very few insects are problematic. Whitefly has been noted in New South Wales to have a particular liking for sesame and this could be a potential future insect problem.

In Australia we already have significant populations of silver leaf whitefly; these have been noted in research trials conducted on sesame by the NSW Department of Primary Industries.

Silver leaf whitefly also occasionally cause problems in south Texas and around Uvalde, however planting early enables crop development prior to the whitefly populations building to significant numbers.

Sesaco has also developed several tolerant varieties, which can tolerate the insects without being killed.

6.3.5 Weeds

Weed control can become a problem. Currently there are no registered herbicides for use in sesame in America. However research to find suitable herbicides are ongoing in the USA. Inter-row cultivation is an option used in wide row spacings in America and could also be used in Australia.

The current reliance is on growers to select paddocks which are relatively free of weeds. Failure to do this can result in paddocks, which suffer from depressed yields as a result of the weed competition and additional problems with harvest and the delivery of sesame with high weed seed contamination.

Herbicide trials in the USA have shown promising results using products such as Stomp® (pendimethalin), Treflan® (trifluralin), Dual® (metolachlor), Fusilade® (fluazifop–p), Verdict® (haloxyfop)and Sertin® (sethoxydim). (Peter Dotray, 2006 personal communication and James Grichar, Texas A & M University, 2001 Crop Protection Journal). Some problems have occurred when using Stomp® (pendimethalin) and Treflan® (trifluralin) at full rates.

6.3.6 Time of Planting

Ray Langham (Sesaco) has conducted several time of planting studies as have many other researchers around the world. The conclusion Ray Langham has drawn from his studies is that cumulative day length hours has a higher correlation to yield than the accumulated degree days. Degree days are still important for sesame as a crop, meaning the growing regions will always be limited by temperatures if they are not sufficiently high.

The most appropriate time of planting sesame in northern NSW has been previously considered as early to mid December; however with longer season varieties this may require reviewing.

The opportunity to plant sesame prior to December in New South Wales would offer greater yield potential according to Ray Langham’s works as the plants would be exposed to a combination of more cumulative daylight hours and degree days.

Planting sesame in late spring in New South Wales would mean a better fit in the rotation. Sesame could then be planted after sorghum or sunflowers from the previous summer, termed a short fallow. This would also allow for sesame to be included as a double crop opportunity, with sowing occurring immediately after winter cereal harvest, depending on sufficient rainfall.

An issue with this type of double crop situation would be controlling sunflower volunteers and contending with quite a dry soil profile and high stubble residue following sorghum.

6.3.7 Harvest Timing

In seasons where frequent rainfall occurs during the harvest period, plant regrowth is possible from several points; eg at the base, middle or top of the plant; regrowth from the top of the plant is the most common. This demonstrates the indeterminate nature of sesame.

Harvesting in Texas, USA often occurs after several rain events have weathered the crop meaning shatter resistance and tolerance to sprouting is very important. This need is exacerbated by the fact that a high proportion of growers leave their sesame crops to last to be harvested of their summer crop area.

The receival standard for moisture content in the USA is 6% however delivery below this level is quite common, meaning a lower yield to the farmer. More accurate timing of harvest would enable seed to be delivered closer to the receival moisture standards.

A method of identifying when the crop has reached the ideal harvesting moisture would be helpful. The difficulty appears to be largely in the colour of the plant stems, as stem colour varies between varieties when the moisture is optimal for harvesting. Generally harvest is considered possible when the plant is a golden brown colour. A colour chart system with photographs demonstrating the different stages is recommended. This would need to be variety specific as there are variations in colour between varieties. Also the benefits of a chart need to be coupled with some experience in interpreting it as different seasonal conditions may promote variations in plant colour within the same variety.

Harvesting closer to 6% moisture content would result in a better quality harvest as less dry, brittle plant material would need to be threshed through the harvesting machinery. A higher yield for farmers would also result, as there would be less weight lost in moisture.

Currently the sesame plant is allowed to naturally defoliate and dry down which is a much slower and more variable process compared to the use of desiccants.

The use of desiccants has been partially investigated and work is continuing. The use of desiccants would promote more even drying of the crop, enabling earlier harvesting, a more uniform seed sample and potentially a cleaner, higher quality sample which contained less trash and moisture variability. Investigations into the use of desiccants are ongoing.

Fields with many volunteer plants regrowing from shattered seed pre-harvest were seen in Texas during the 2006 season. This is a result of the variability of capsule ripeness on each plant. The indeterminate nature of the sesame plant means capsule ripeness is often at several stages on an individual plant and this is exaggerated on a whole field basis. Individual plants may have bottom capsules which are completely ripe and open while the top nodes of the plant are still flowering.

The 2006 season had quite unusual climatic conditions which prompted the high number of volunteers, including several rainfall events during harvest. The use of a desiccant would assist farmers with commercial fields of sesame to even up crop dry down and control young volunteer sesame plants. However crops destined for seed retention purposes do not have any option to use desiccants as the products may reduce seed germination levels.

6.3.8 Harvest Machinery

Several types of headers can be used to harvest sesame, including row crop headers (eg harvest six planted rows) and headers with long fingers similar to crop lifters with a normal auger and other variations of this. However Ray Langham commented that the experience and skill of the header operator is more important in many ways than the header setup.

The operator in Photo No 3 commented that he was driving at 5 miles per hour, using a John Deere header with a fan speed of around 730 rpm, concave set at 710rpm and the drum speed at 430 rpm. This particular crop was being harvested at 5.9% moisture content which is ideal for delivery.

As sesame has a tendency to throw its seed from the seed capsules most farmers have added a board or a clear piece of perspex to the top of their comb to block seed from coming over the front. The Perspex was the best method which I observed as it still enabled a clear view of the front by the operator.

Photo No. 3 Harvesting with a row crop header near Uvalde, Texas. The timber board above the comb can be seen here. Also the crop displays the common green stems often remaining at harvest, whilst the majority are golden brown. Note the large number of volunteer sesame plants in the field.

Plant breeding by Ray Langham (Sesaco) has developed excellent levels of shatter resistance compared to the current levels available in Australia. The capsules have several unique characters, which have been developed through years of selective breeding. These characters combined with effective header setup minimise crop losses.

Transporting the seed is another area where quality needs to be maintained. Truck bins should be clean and tarps should be used to cover the load to prevent loss from the small seed blowing out and to prevent other contaminants eg from birds entering the load.

7 Sunflower – The Need for Diversity

Sunflower is not a new crop to Australia; in fact it has been grown here for many years. In the last decade sunflower production and area in the state of New South Wales has reached peaks of around 70,000ha to provide between 90-100,000 tonnes of seed. These highs occurred in three seasons, 1994/5, 1998/9 and 2005/6 however the average crop area sown to sunflower in NSW is more in the range of 20-30,000ha. These average areas are in sharp contrast to figures from the 1970's and 1980's.

Overall the area planted to sunflower has significantly declined over the last twenty years. Over the past three seasons, there has been renewed interest in the crop. Sunflower production in Australia historically has been highly variable.

Sunflower research and investment in development as a result has declined in line with the area of the crop grown, resulting in little current research available and being undertaken to support farmers who choose to include the crop in their rotations.

7.1 Alternative End Uses

Sunflower is currently used for one major purpose in Australia, crushing for the extraction of the oil. The market is dominated by a couple of major players, who while continuing to try and support the Australian industry, face the economic reality of cheaper import competition.

A portion of the lower cost of imported product is due to government subsidies commonly provided to international farmers and which are not available in Australia.

However, as an industry the challenge is to provide alternative end use options for sunflower. The secondary market in Australia is the confectionary/ stockfeed market which is much smaller, but has a much greater potential for expansion.

Photo No. 4 Loretta Serafin inspecting a sunflower trial at the International Symposium on Sunflower Industrial Uses, Udine, Italy.

7.1.1 Value Adding for Human Consumption

The United States displays a much wider range of products utilising sunflower in local supermarkets and generally available and accepted by the consumer than in Australia.

This product range is targeted at the everyday consumer, not just the organic or natural sections. Products available include a range of breads, cereals, snack bars, oils, cakes, birdseed, horse-feed, spreads and confectionary items including roasted kernels and chocolate coated kernels. In comparison there are relatively few opportunities for the Australian consumer to include sunflowers in their daily diets.

I had the opportunity to visit with Red River Commodities, a confectionary producer of sunflower in Fargo, North Dakota, a small company which has value added successfully in a number of ways. Two of their products available to consumers in supermarkets are:

a. SunButter

An alternative product with similarities to peanut butter. SunButter is used as a spread on sandwiches and other bread products. It has gained significant popularity in the USA since its release by Red River Commodities.

SunButter is a product with a taste, look and consistency similar to peanut butter. Its development has fitted into a niche market due to the high number of people with allergies to peanuts. SunButter provides an easy and safe alternative. The product has been moved onto the approved list in several school canteens aiding its success. It is available in a range of variations including smooth, crunchy, honey crunch which tailors its fit in the community to younger children. SunButter uses a short and simple list of ingredients, the most important of which is sunflower kernels.

b. Sunflower Kernels

American consumers have a range of sunflower kernel products available to them. The sunflower seeds which have simply been sorted and dehulled are then sold in a form similar to purchasing nuts as a snack food in Australia. They are available salted, roasted, plain and in many other flavours.

In addition the larger kernel confectionary sunflower kernel types can be used in the “chew and spit” market, where the sunflowers are sold in hull and the consumer then chews on the whole seed, eating the kernel and spitting out the hull.

7.1.2 Industrial Options

a. Biodiesel

Biodiesel is a topic of high interest because of the relatively high fuel costs currently being experienced in Australia. Sunflowers are an oilseed crop with potential for use in formulating biodiesel. Biodiesel plant efficiency is based on the largest amount of biodiesel produced from the use of the least amount of energy. As a fuel source biodiesel has advantages including being a renewable energy source with lower emissions for most aspects.

The first international symposium on sunflower industrial uses in Udine, Italy presented information on biodiesel production. One key speaker was Mr. Steve Austin, from a company called SunBio Systems Inc. based in the USA. Mr. Austin commented during his talk that 1,000kg of seed is the minimum economically viable amount of sunflower for producing biodiesel in a plant. Mr Austin's presentation outlined the production of Biodiesel in the following manner. Starting with 2500kg of sunflower seed entering into the biodiesel plant, you will remove 1400 kg as a protein cake and 940 kg of oil. After the oil is degummed the remainder will be around 840 kg of biodiesel.

Producing Biodiesel is a 4 step process:

1. Press Seeds
2. Extruder
3. Press the seeds again then split into oil and a protein cake
4. Degum the oil and it exits the system as biodiesel.
5. Optional: Reuse some of the biodiesel produced to supply energy to run the plant.

The disadvantages of biodiesel are related to its storage life, quoted as being a maximum of 6 months. However as a product it is considered safe to handle. It is important to maintain the quality of the biodiesel through regular testing and ensuring water does not enter the holding tanks.

The European Union and in the USA have mandated the replacement of diesel with 5% biodiesel by 2010 and 10% by 2020. This is the same in the USA.

Considering the opportunity for small sized biodiesel plants, biodiesel offers a potential option particularly for farmers who are already growing oilseeds such as canola and sunflower and could use the biodiesel for their own use. The major issue with small size plants is quality control of the biodiesel to prevent bad quality product potentially damaging machinery when the product is used. Also there is a need to utilise the protein cake by product.

However, establishing a biodiesel plant as a commercial venture still requires more research and development, particularly in the areas of plant construction, transport, by product uses and potential government support.

7.2 Ways to Improve Yield and Oil Content

7.2.1 Nutrient Management - Nitrogen

Nitrogen is the major nutrient applied to sunflower crops. In work conducted by my colleague Stephanie Belfield (NSW Department of Primary Industries, District Agronomist Moree East) and myself, it has become evident that there are major variations in the amount of nitrogen supplied to sunflower crops in the growing regions of northern NSW and southern Queensland.

In the Liverpool Plains region of northern NSW average applications of nitrogen are in the range of 100 units of nitrogen/ha for each crop. This is sufficient nitrogen to produce a crop of 2.5 tonnes per ha, nearly 0.75t/ha higher than the long term average yield achieved in this area. In comparison, sunflowers in the Moree district receive little or no nitrogen.

This leads to the question of the effects of applying excess or insufficient amounts of nitrogen on crop growth, water use efficiency, crop yield and most importantly oil content.

The oil content required by end users is set at 40%, below which farmers receive price penalties on the amount they are paid in Australia. Conversely oil contents above 40% attract a premium.

Nitrogen budgeting for optimal crop oil content has been studied in great depth in France. The relationship is best explained as, when sufficient nitrogen is available to achieve maximum yields, the oil content has been decreased. Conversely, nitrogen deficiency in sunflowers prior to flowering reduces the number of seeds set per head, which equates to a reduction in yield.

In order to balance these two important factors, optimum yield and high oil content, growers need to be able to identify the desired amount of nitrogen. To establish the amount of nitrogen in the soil a soil test prior to planting is the easiest method. This then enables a nitrogen budget to be completed.

However, alternative management tools used in France include:

a. *Heliotest*

Heliotest ® is a nitrogen management program designed by Cetiom, France.

This program advises farmers not to apply any nitrogen to the majority of their field at planting. They are advised to apply their normal rate of nitrogen to one strip in their field; this is regarded as the test strip. The amount of nitrogen applied to this strip is usually between 60 and 80 units of nitrogen, which is the standard nitrogen application rate in France.

The growers using this program then observe their sunflower crops closely from the 7-8 leaf stage through to the 14 leaf stage for differences between the crop and their test strip in leaf colour or plant height.

At the time when they visually see a difference between their crop and the test strip they apply nitrogen based on their target yields and the information provided on their Heliotest cards.

For example, for a target yield of 2.5t/ha the growers should add 30 kg N/ha when a growth difference is observed at the 7-8 leaf stage. 70kg N/ha is added if the target yield is 3.5t/ha and the difference is observed at the same stage.

If no difference is observed between the paddock and the test strip up to the 14 leaf stage then no nitrogen is added to the paddock. The amounts of nitrogen and target yields are all supplied on a calendar type document which can be sourced from Cetiom.

Heliotest is a concept which aims to reduce grower input costs for nitrogen, hence providing an economic benefit. In addition, Heliotest helps maximise the oil contents of the crop by ensuring over fertilisation does not occur and optimises yield.

Seasonal conditions would still need to be taken into account when using Heliotest to ensure adequate moisture is available to allow any additional nitrogen added to become available to the plant for conversion into yield.

7.2.2 Harvest timing for grain moisture management

Growers are generally harvesting sunflowers at 2-4% lower moisture than the receival standard in Australia. This delay in harvesting means a considerable loss in yield to the farmer.

This also promotes issues with the percentage of admixture in a sample of sunflowers. Drier plants and stalks tend to shatter and are more difficult to separate from the seed during the harvesting process.

In addition the longer physiologically mature sunflowers are left standing in the field, the higher the risk of yield and quality losses from rain and storms.

The problem with harvest timing also occurs in the USA and France. In order to minimize losses in seed and oil yield and quality, growers are encouraged to harvest as soon as practical. This often means following the first frost in the USA.

A harvesting publication showing timing of harvest and the stages from plant physiological maturity through to harvest would be beneficial. This could demonstrate that plants with partially green stems often contain seed below the receival moisture limit.

7.2.3 Broadening herbicide availability

Herbicide options for broadleaf weed control in Australia are limited and the main options available are not suitable for use on no-tillage farming systems, which are very common in northern NSW, Australia.

The current broadleaf weed control options require mechanical incorporation of the herbicide, which is not possible in a no-tillage system, the herbicides are too expensive, or they control a limited spectrum of weeds.

Sunflowers are removed from summer crop rotations in many cases due to the additional weed populations caused by a lack of weed control options. Farmers who persist with sunflowers on a regular basis often contend with a sunflower crop with a high population of weeds and the additional weed competition for the following crop. These result from weeds being allowed to set seed during the sunflower phase.

The USA has several similar herbicides to Australia including pendimethalin and trifluralin products. However it is the alternative options available in the USA which would allow better weed management in Australian sunflower crops. The Clearfield™ technology allows use of a herbicide called Beyond® (active is Imazamox) belonging to the imadazoline group of herbicides and manufactured by BASF. The Clearfield™ system involves using sunflower hybrids which are naturally tolerant to the herbicide. This offers an alternative herbicide to broaden the spectrum of weeds controlled and rotate the group of chemistry used for weed control. Several other options also are available ,such as sulfonylurea herbicide tolerant sunflowers, these are being evaluated for introduction in the USA.

A wider range of herbicide options would enable a better fit for sunflowers in the rotation and higher yields as a result of less weeds competing for moisture and nutrients.

7.2.4 The use of a harvest aid

Evaluation in North Dakota, USA is continuing into a range of products for potential use as harvest aids to speed up dry-down of the sunflowers, enabling earlier harvesting and preventing the sunflowers from continuing to use soil moisture.

The benefit of applying a harvest aid to sunflower is in the ability to reduce the moisture content in the plant and the seeds more quickly.

In the USA, harvesting is a challenge which needs to be completed prior to the winter freeze and snow fall.

In Australia similar technology would mean earlier harvesting resulting in less risk of weather damage in the field from summer storms, a better quality sample as farmers should have less variability in plant moisture content across a field and enable harvesting at moisture levels closer to the receival standards.

Also the opportunity to start storing moisture in the soil profile and controlling weeds earlier in the fallow period would be of great benefit.

However a risk with using harvest aids, as seen in other crops would be the possible effect on crop standability as the plants may be more prone to lodging.

7.2.5 Time of planting

Monounsaturated sunflowers are the main type of sunflower grown in Australia. They have a higher percentage of oleic acid; hence they are called high oleic sunflowers.

The receival standard for sunflower oil content is 40% and a minimum of 80% oleic oil content. Growers currently either receive a bonus or penalty off their total payment per tonne upon meeting or failing to meet the 40% oil content standard. In most seasons in Australia the total oil content is not achieved, while the oleic oil content is easily achieved.

Studies in France demonstrated that high temperatures from flowering to maturity affect sunflower oil quantity and quality. Sunflowers exposed to high temperatures in the two weeks following flowering produced less oil with higher oleic acid than sunflowers exposed to more moderate temperatures. (Anne-Marie Triboi-Blondel et al, INRA, France).

If planting times could be moved to an earlier date in spring in NSW Australia to avoid an excess of heat in the two weeks following flowering, the oil contents should be higher, whilst still maintaining acceptable oleic oil contents.

The current recommended planting time is closely related to when the soil temperature reaches 10-12 degrees Celsius and the risk of frost damage is minimised. The soil temperatures are often achieved in late August in northern NSW and sunflowers can tolerate some frosting.

As an alternative, farmers could also evaluate late-season sowing, currently mid December to mid January. Sowing in late January might be possible with the use of a harvest aid to enable quicker dry down at the end of the season.

8 Recommendations

Summer oilseeds in Australia would greatly benefit from:

- Support for an alternative crops program in the New South Wales or Queensland Department of Primary Industries to provide knowledge and support for farmers diversifying their summer crop rotations.
- An exchange program for Australian and USA farmers. With the opportunity to visit an area of similar climatic and cropping systems, the program would be aimed at fostering development of alternative crops, end use options and a greater understanding of agriculture on a world scale.
- Continued development of networks and investigation of possible collaborative work with researchers in the USA, Italy and France.
- An alternative crops conference or section in the summer grains expo planned for Australia in 2009.

Sesame specific recommendations:

- The development and support of a national sesame breeding program, including the importation of alternative germplasm, such as from the United States Department of Agriculture collection to expand the current genetic pool available for breeding.
- Continue trial work on necessary agronomic requirements for growing sesame in Australia, including basic row configuration, herbicide, insecticide and desiccant options.
- Continue to develop a relationship with Sesaco and also other sesame breeders and researchers on a worldwide basis to ensure the exchange of information for faster adoption of suitable technologies for the industry.
- Compile all current Australian knowledge on sesame into a publication for interested growers and researchers

Sunflower specific recommendations:

- Provision of and support for the development of a biodiesel plant in the north-eastern zone of Australia to offer alternative uses for sunflower and other oilseeds, for example canola. This would also assist in providing a cleaner source of fuel for vehicles and a value adding opportunity for local communities.
- Implement nitrogen management techniques similar to Heliotest. There is a need to evaluate the current high use of nitrogen in the more favourable dryland areas. Develop a nitrogen budgeting publication for sunflower growers in northeastern Australia.
- Develop a harvest timing publication between the Australian Oilseeds Federation, Australian Sunflower Association, NSW Department of Primary Industries and the Queensland Department of Primary Industries. This publication would include photographs of the various stages of sunflower growth from physiological maturity to harvest ripeness.
- Conduct of research showing the time duration between physiological maturity through to harvesting moisture.