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Alternative Oilseeds R&D for Biodiesel Production (2001)

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Department of Agriculture Bio-Diesel Initiative
Mission Statement

To facilitate the development of a WA based bio-diesel industry with industry partners by providing targeted research initiatives. These initiatives would be on production and processing of suitable oil crops and trees that will improve the profitability and sustainability of rural communities throughout Western Australia.

BIODIESEL RESEARCH AND DEVELOPMENT WESTERN AUSTALIAN DEPARTMENT OF AGRICULTURE 2000 – 2001

Background

There is a slow but growing realization that crude oil is our weakness component in Australia's energy portfolio. Australia's domestic reserves of heavy crude oil, which is essential in the production of petroleum diesel, it expected to reach exhaustion by 2012 on current usage patterns. A need to become more heavily dependant on import crude oil will impact on our balance of trade and further expose our transport and rural sectors to international oil price fluctuations.

Biodiesel is widely known an excellent alternative to mineral diesel and has been extensively demonstrated in the EC and the United States. It is a renewable fuel made by reacting 20 parts of Canola oil with one part methanol or ethanol (grain alcohol), injecting hot water through the mixture and allowing to cool. The Biodiesel naturally separates from the water solution, with no further refining or processing required. Biodiesel has the same combustion properties as regular diesel with considerably lower levels of polluting emissions (appendix 1). Bio-diesel has been found to be a cleaner fuel than diesel, resulting in lower engine maintenance costs and that it can be used in current diesel engines with virtually no modification.

The production and use Biodiesel has not been explored to any great lengths in Australia. The Department of Agriculture WA has undertaken an initiative to lead the development of this promising biofuel sector and improve the economic fundamentals for Biodiesel production and use in Western Australia.

The Department of Agriculture WA recently initiated some preliminary investigation in June 1999 with a brief desk-top study on value adding in the pulse and oilseed industries. It is not the first time the Department has investigated alternative fuel sources, during the energy crisis of the early eighties sunflower crops were evaluated on the south coast for their potential as a biodiesel crop. These trials met with limited success and once the crisis abated the research stopped.

A recent report on biodiesel found that canola oil was too expensive as a fuel or even as a blend compared to petroleum diesel (Kingwell, 1999). But this has not deterred the department from further investigations into this area of bioenergy because of its environmental benefits and the likely significant role agriculture will play in the production and utilisation of bioenergy in the future. Western Australia Agriculture is in a good position to develop potential bioenergy crops in the future.

Biofuel crops could potentially play a key role in minimising further environmental degradation of our fragile landscapes, particularly in the Southern Agricultural zone where salinity has emerged as a major threat. High value oilseed and biomass crops could help finance landholders own land rehabilitation programs. Biodiesel is just one of many fuels which can be generated from the biomass of agricultural crops. Today some of the best species which lend themselves to fuel production are the oilseed and tree crops like canola and olives, both of which are already adapted to out Mediterranean environment.

Biodiesel for WA

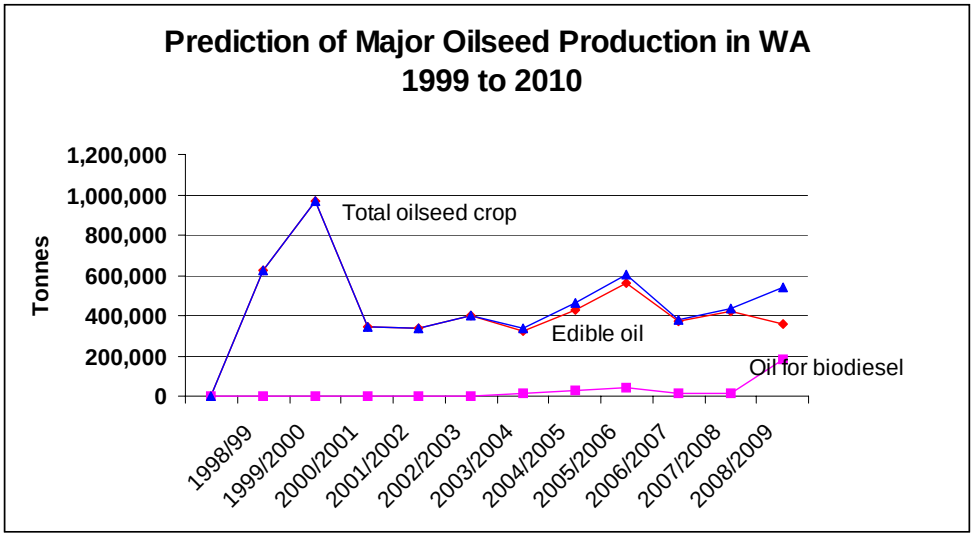
Bio-diesel is well known as a clean, "green", engine fuel with potential for broad application in the transport, mining, fisheries and forestry industries of Western Australia. The environmental benefits of Bio-diesel have been established over the last thirty years in Europe and North America where it is widely used as a transport industry fuel in large urban centres with poor air quality. These benefits are well documented and are not the focus of this brief.

A preliminary desk top study has indicated that a Western Australian Biodiesel would be a viable alternative to petroleum diesel, especially in the environmental sensitive industries like mining and urban transport. Even without tax breaks the fuel has enormous benefit in terms of reduce emissions.

The potential size of a biodiesel industry could match current production of canola in WA, 300,000 to 400,000 tonnes per annum. The South West Agricultural Region in Western Australian has proven its ability to produce up to 1 million tonnes of canola in one season (1999). Even if half of this volume was converted to biodiesel, it would represent over 155 million liters of biodiesel. It is possible that the industry could be build upon a series of regionally based small crushing plants delivering to a centralised fuel processing plant. In some regional centres further value adding could be made through refining the oil before processing into biodiesel at a central plant.

There is a need for multi-Departmental program into the development of a biodiesel within WA, combining the resource of the Departments of Agriculture, Transport, Trade and Commerce and Mining. This program would initially need to build linkages between producers, researchers, manufacturers and refiners to establish a blueprint from which the industry could to be built.

Graph 1 Projection of oilseed production in Western Australia based on canola and new biofuel crops production trends.



The Department of Agriculture would take a lead role in this industry development project because the success of the industry hinges upon profitable and sustainable production of oilseed crops, like canola, olives and mustard. The program would also link with existing sustainable resource management projects to develop crops for saline affected land and help restrict further degradation of the landscape. Two key elements in the development stage of the industry would be germplasm improvement and a processing/refining research unit. The Department of Agriculture would build upon existing germplasm resources for the project and processing would be established by using existing resources of the various departments.

A Bio-diesel production and utilisation pilot plant should be established in WA to evaluate the feasibility of all potential oil crops including canola and related species, oil trees (e.g. olives, tallow tree) and even algae for their suitability for large scale esterification within the WA environment. Industry partner would need to be pulled into the agreement, with Woodside and Saarberg as potential primary candidates.

Western Australia is considered an ideal environment for the production of biodiesel industry; the state is already recognized for its expertise in energy policy and industry development. A number of other factors are;

WA's natural advantage in cost–effective, broadacre oil crop production, especially canola and olives,

Department of Agriculture has access to existing and international oilseed crop germplasm, plant breeding infrastructure and expertise in industry development,

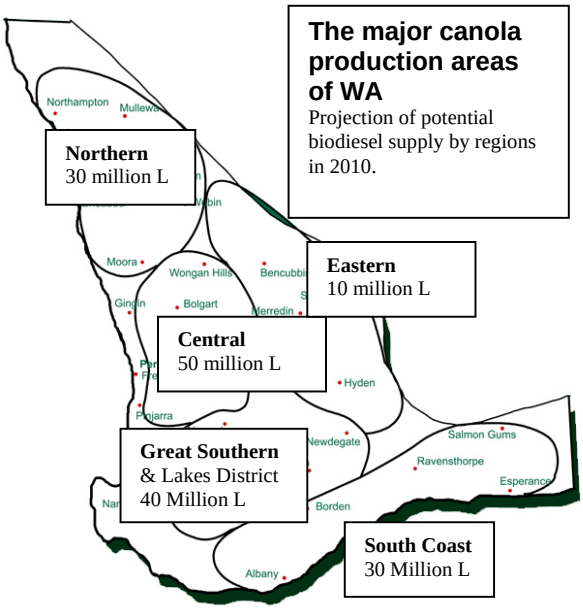
Department of Minerals and Energy has a number of innovative projects in renewable energy use in regional WA.

Remote rural and urban communities are now ready to accepted alternative fuels for power generation and transport to give them more flexibility and a better environment to live in,

Our pristine marine environment is in need of stricter regulations in fuels currently being used, especial in recreational boating. There is a need to protect our fisheries resources against non degradable mineral oils; the use of biodiesel in recreational boating is a small step in the right direction.

The size of the south-west agricultural cropping industry (>6 million hectares per annum) ensures a continuity of supply can be achieve through the diversity of oil crops and trees that can be grown in WA.

The most recent desktop analyses by Department of Agriculture has indicated that the current WA operating costs for Bio-diesel, with no by-product credits, will be between 80 and 97 cents per litre.
The Department of Agriculture plans to develop new oilseed varieties with combined yield and oil contents 20% greater than those currently in production in WA. Oilseed growers could receive at least the same per-hectare return as for their current oilseed crops. Regionally produced Biodiesel would be highly competitive with fossil fuels both within Australia and overseas. Its development would bring much need value adding to our regional communities.
Department of Agriculture strongly believes that these objectives are achievable within the decade, to have a biodiesel industry which produces over 200 million litres of biodiesel in the south-west agricultural region of Western Australia. A solid foundation of work in the canola industry has been completed to date making this low risk research and development which has enormous economic, environmental, and security upside for Australia in terms of energy generation.



Development of oil crops for WA

The long-term, sustained economic viability of a Bio-diesel industry in WA is closely linked to the development and implementation of higher performing oil and olives to supply Biodiesel production. At present Department of Agriculture has an extensive collection of canola material, all potentially suitable for biodiesel production in Western Australia. It also has access to a wide variety of other oilseed germplasm both nationally and internationally which has been identified as suitable for conditions in the Western Australian agricultural zones.

Traditional breeding programs which develop canola varieties for human consumption bred undesirable characteristics out off the parent lines and in doing so some natural adaptability is lost. By reviewing some of the original parent lines or alternative species better adaptability can be selected for without the quality constraints that are required for human consumption canola. It is through this principle that Department of Agriculture would exploit the full potential of existing oilseed crops and increase the oil yield and oil content of canola varieties on a per hectare basis over the next 3 years. The Department of Agriculture will utilise its fast tracking breeding and evaluation programs and extensive network to screen for such material.

The ability to achieve higher yields and higher oil contents is crucial to the success of any sustainable biodiesel industry in Australia, as is the availability of skilled producers to grow the crop. The release of biodiesel specific lines would be rapid and within 3 year of the program commencing deliver economic benefits to growers and end-users immediately. Department of Agriculture is confident its can build for the first time in Australia a world class facility designed to deliver oil crops design specifically for biodiesel in dry environments.

CURRENT WA BIODIESEL RESEARCH PROGRAM, 2000 - 2001

Initial trial and evaluation activities have been focused on using oilseed varieties already identified well adapted for broadacre farming in Western Australia. Canola (*Brassica napus*) will be the focus of this program as it is currently widely grown in WA. Other potential Biodiesel species have been identified and are currently under going field testing in the grainbelt of Western Australia, these species include;

Species	**Common name**	**Type**	**% oil in seed**
Brassica juncea	Indian Mustard	canola-like	35 – 40 %
Brassica carinata	Ethiopian Mustard	canola-like	38 – 42%
Brassica nigra	Black Mustard	hardy canola type	38 – 42%
Sinapis alba	White mustard	condiment mustard	36 – 40%
Camelina sp.	False Fax	low rainfall type	40%
Eruca rucola	Erucola	drought tolerant	?

Over the last two seasons The Department of Agriculture has conducted a limited number of trials using existing canola material and some additional closely related species to evaluate their potential for use as a biodiesel plant/crop species. The aim of the work is two fold;

1. Firstly, to determine which of the closely related species of Crucfierous (canola type plants) family are immediately the most suitable for biodiesel production in the dry environment of Western Australia? Evaluate them for seed yield, oil concentration and oil yield (Yield x % oil concentration).
2. Secondly to increase the efficiency and thereby reduce costs of biodiesel production in WA by identifying those lines that are capable of giving high oil yields per hectare.

The oilseed crops in these trials were either edible or industrial vegetable oils, there being no difference for the production of biodiesel.

In 2000, three trials investigated the productivity of *Brassica napus* (canola), *B. juncea* (Indian mustard) and *B. carinata* (Ethiopian mustard). The trials were located in the Geraldton, Wongan Hills and Merredin districts of the Western Australia grainbelt (see canola production map of WA).

The best oilseed species in terms of oil yield was *B. carinata* which gave 72% higher oil yield than *B. napus* variety Monty, the early maturing canola variety. The best performing Indian mustard oil yield was on average only 80% that of Monty.

In 2001, the Department has continued to evaluate these three *Brassica* crops at four locations in WA; Newdegate, Avondale, Merredin and Wongan Hills. Within each crop species, a greater number of lines with high oil concentrations are being tested. Results will be available at the 2002 Department of Agriculture Crop Updates, 23 February, 2002.

Potential further WA research

Further research needs to be conducted into other oilseed crops which are better adapted to our northern agricultural zones in Western Australia. A revisit to previous research conducted on the Ord irrigation area should be made, especially for sesame, sunflowers safflower, peanuts, and cotton as potential supplies of biodiesel to isolated communities in the north of the state. The potential for palm oil and "dryland:" palm oil trees (*Elaeis guineensis*) also need to be investigated as industries in their own right and as a source of biodiesel in the north. Initially research should include reviews of literature and testing the most likely candidates with CSIRO Bioclimate model for the different species suitability before any trial program is initiated.

There are many species that have yet to be evaluated in Western Australia from a biodiesel perspective. Preliminary research into the most promising crops should be made over the next 5 years to improve our understanding of how they perform in dry environments and there potential to contributing to groundwater management. A diversity of species could be drawn upon in the future to supply an expected growth in demand for biodiesel throughout the world. It is recommended that other potential oil bearing plants that should undergo some preliminary studies in Western Australia are listed below:

Species	**Common name**	**% oil in seed**
Lesquerella spp.	Lesquerella	30
Linum usitatissmum	Linseed	38
Seamun indicum	Sesame	50
Sapium sebiferum	Tallow tree	55
Limnanthes spp.	Meadow Foam	24 - 30
Lupine spp.	Pearl Lupins	15
Cannabis sativa	Hemp	30 - 35
Elaeis guineensis	Palm oil (African spp.)	40 – 50%
Salicornia bigelovii	Glasswort (salt tolerant spp)	26 – 33%

Industry development approach

First it will be necessary for the Department to appoint a bioenergy industry development officer who would provide a focal point for the development of a biodiesel industry in Western Australia over the next five years. An appraisal of the current biodiesel industry in WA and a re-visit of previous economic studies in the industry need to be done. An outline of carbon budgets for biodiesel made from canola and related crops would also form part of this initial assessment. This would be done with the support Departments extensive range of professional research staff ranging from engineers, chemist and agronomists. On-farm energy budgets would be a direct activity of the development officer. This carbon accounting would run parallel with Western Australian Department of Agriculture Trade and Development's scoping exercise in market development opportunities for biodiesel both domestically and internationally.

Through the application industry and market development models from Western Australian Department of Agriculture Trade and Development the office at the end of the project should be able to outline a strategic development plan for the industry for 2003 to 2008. The project team would investigate case studies from elsewhere in Australia and overseas and build a blueprint for industry development in WA. This could be then used to formulate policy recommendations for the Minister for Agriculture, Forestry and Fisheries of Western Australia.

Western Australian Department of Agriculture would also conduct a feasibility study on the viability of regional biofuel plant, testing various models for business structure in rural communities. The study would include economic analysis of short rotation oilseed crops in different production zone of WA grainbelt. Performance of alternative oilseeds including weedy species like wild radish would be assessing using the mobile unit to determine their potential output and suitability as a source for biodiesel. A mobile unit would provide the best technique establish environmental variations in extraction efficiency and fuel quality of the various species. The species initially to be tested are *Brassica napus, B. carinata, B juncea, B nigra, R rustrihium.* Western Australian Department of Agriculture's Oilseed Genetic Improvement Project would evaluate alternative oilseed crops for production potential and the best genetic traits for suitability as a source of biodiesel. They would be responsible for bulking up of suitable lines of new industrial oilseed species for batch processing and evaluation in the mobile unit.

An important role of the proposed project will be to promote public awareness of biofuels with interactive displays and demonstrations at major agricultural field days and the Perth Royal Show. The real benefit of this project is to clearly identify the suitability of oilseed crops for biofuel production and how they could aid in Australia meeting its Kyoto Greenhouse Gas Emission objectives.

APPENDIX 1

BENEFITS AND DISADVANTAGES OF BIODIESEL

Benefits

1 Biodegradability
When using 100% biodiesel, any spillages onto soil, 95% will have decomposed within 3 weeks of the spill. However, if mixed with petroleum diesel this biodegradability is not realized.

2. Reduced emissions
A 20% blend of biodiesel with a catalytic converter reduces particulates matter by 31%, carbon monoxide by 21% and hydrocarbons by 47%. When it is used as a 100% mixture is sulphur emissions are 0%.

3 Renewable energy
Biodiesel is made from a 100% renewable products. It can be made from food grade vegetable oil or even more cost effectively from wasted vegetable oil. Canola oil makes one of the better methyl esters for biodiesel.

4 Carbon dioxide neutral
The carbon in vegetable oil has been captured by plants from the atmosphere as they grow in the field. It has fixed atmospheric carbon and therefore is a carbon neutral fuel.

5. Engine wear
Biodiesel and blends of biodiesel offer better lubrication which reduces engine wear and lengthen the life of fuel injection systems.

6. Performance
Engines running on biodiesel have low operating noise
It can be used in unmodified diesel engines
It provides the same economy and torque as petroleum diesel.

7. Toxicity
Biodiesel has a low toxicity level and is less harmful to aquatic life and plants

Disadvantages of biodiesel

1 High cost of production
Generally under WA conditions the production cost of one litre of biodiesel from canola oil will range from $0.85 to $1.30 per litre based on canola prices of $350 to $400 per tonne.

2. Low temperatures
In its pure form, biodiesel engines can experienced some difficulty with operating effectively at low temperatures (> -5 ^{o}C) However with some modification to the fuel biodiesel engines can run at (-36 ^{o}C).