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The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics across its 9 member countries: Cambodia, China, Indonesia, Laos, Malaysia, Papua New Guinea, the Philippines, Thailand, and Viet Nam. Its goal is to strengthen local capacity for the economic analysis of environmental problems so that researchers can provide sound advice to policymakers.

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Is Biodiesel an Effective Environmental Solution – A Case Study from China

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As in many countries, policy makers in China see biofuel as a potentially important part of the move to a sustainable, post-oil economy. To contribute to this important energy debate, a new EEPSEA study looks at the economic and environmental performance of one potential bio-fuel crop: Jatropha curcas L (JCL).

The study is the work of Zanxin Wang, Ying Lu and Siguang Li from China's Yunnan University. It shows that, →

A summary of EEPSEA Research Report No. 2009-RR12: 'Producing Biodiesel from Jatropha curcas L. in Yunnan, China: Lifecycle Environmental, Economic and Energy Performance' by Zanxin Wang, Ying Lu and Siguang Li from the Institute of Population, Resource and Environmental Economics, Yunnan University 650091, Kunming, Yunnan Province, P.R. China.
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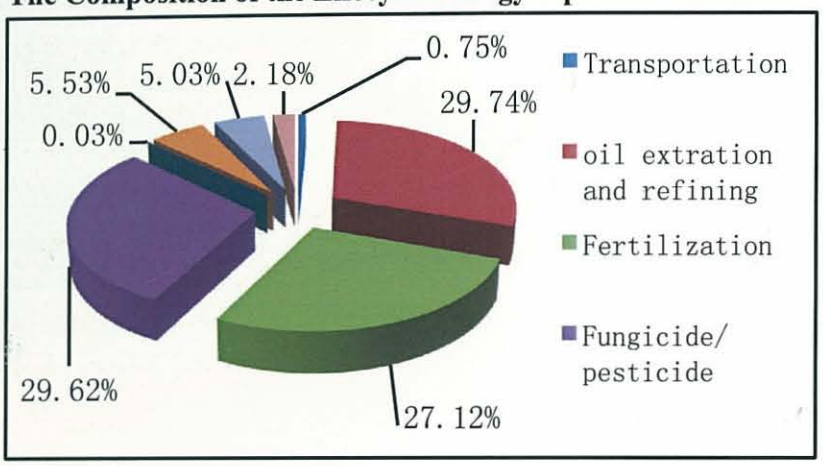
" JCL biodiesel has excellent ...

The Composition of the Lifecycle Energy Inputs of JCL Oil



given current technology levels and management practices, the production of JCL biodiesel is not economically feasible. However, it also shows that JCL biodiesel has excellent performance from both an environmental and energy production point of view. Moreover, it is clear that, if JCL seed yields can be improved, then biodiesel made from the plant would be economically feasible to produce.

With this in mind, the report outlines a number of initiatives that could be pursued to make JCL biodiesel an effective part of China's overall energy policy. These include providing grants and other funding to optimise the JCL biodiesel production process.

The Biofuel Challenge

China is one of the global leaders in the development of biofuels. In 2005, it became the world's third largest biofuel producer with an output of one million tonnes, behind Brazil and the US. However, in 2007, concerns over food security led China's central government to ban the use of grain-based feedstock for biofuel production and the country re-oriented its bioenergy plans towards perennial crops grown on marginal land. Partly due to these policy changes, JCL has emerged as an important potential biodiesel feedstock because of its adaptability to diverse growing conditions.

The commercialization of JCL in China is fairly recent - commercial seedling production began in 2005. Now, about 33,000 hectares of JCL grow naturally in Yunnan, Guizhou and Sichuan provinces and provincial governments in Southwest China have drafted plans to increase the area of JCL cultivation by over one million hectares in the next decade.

What Makes a Viable Biofuel?

To be a viable alternative to fossil fuels, biofuels should produce more energy than they take to grow and produce (ie. yield a positive energy balance), have environmental benefits and be economically feasible. They should also be able to be produced in large quantities without having a significant impact on food security. Many biofuels do not meet all these prerequisites. Indeed, a recent study has found that 12 kinds of biofuels have a greater environmental impact than fossil fuel. These include corn bioethanol in the US and palm biodiesel in Malaysia.

There is still a lack of information on the environmental, economic and energy performance of biodiesel production in China. To provide this kind of vital information, this study assesses all key aspects of performance of JCL biofuel production and use. To do this, a lifecycle "cradle to grave" analysis was carried out on the biodiesel production system. The seeds of JCL can produce oil for direct blending with fossil diesel. This oil can be further processed into JCL methyl ester (JME). The production of both of these end products was assessed.

While many provinces in China are involved in producing biodiesel, Yunnan Province was selected as the study region. Yunnan Province aims to build the largest biodiesel base in China. This is because the province has the right climate and land availability for JCL cultivation. It also makes sense to develop biodiesel in the province, because it has no oil fields or refineries.

environmental and energy production performance."

The Economic and Environmental Viability of JCL Biodiesel

The life cycle assessment covers the cultivation, harvesting and transport of JCL seeds, the processing and preparation of the seeds, the extraction and refinement of oil and the distribution of JCL biodiesel. The assessment also takes into account the consumption of JCL biodiesel by vehicles and other engines. It looks at all the inputs and outputs of the process: from agricultural chemicals to vehicular air pollution.

Among the study's specific objectives are an assessment of the following issues: the financial viability and economic efficiency of the production of JCL biodiesel; the energy efficiency of the production of JCL biodiesel; and the impact of biodiesel production on land use. The study also considers the amount of carbon produced by the JCL biodiesel production chain. To get a true picture of the feasibility of JCL production, the environmental impact of biodiesel production (in terms of its carbon balance) is integrated into the economic analysis. The overall results are then analyzed to find out the cost-effectiveness of biodiesel production.

A wide range of information is used in this assessment. Primary data was collected through field surveys and discussions with producers at different stages of biodiesel production. For example, the primary seed production data was collected from Honghe and Chuxiong Prefectures, areas in Yunnan Province where Jatropha plantations have been developed on a massive scale. Technical oil extraction data was collected for Erkang Science and Technology Co. Ltd, a vegetable oil producer. Secondary data came from published journal articles and books.

How JCL Biodiesel Performs

When no other external values are included, it is clear that the production of both JCL oil and JME is not economically feasible (ie. no profits can be made from its production). However, if seed yields can be improved to above 2.46 tonnes per hectare, both JCL oil and JME will be economically feasible to produce.

The production of JCL oil and JME both score well from an energy production and from an environmental point of view. The production of both fuels has a positive energy balance, although the production of JCL oil is more energy-efficient than the production of JME. This is because the production of JME includes the transesterification process. The production and use of both fuels produces an overall reduction in carbon emissions (when compared to the use of normal fuels). The rate of reduction is 7.34 kg CO_2 per litre for JCL oil and 8.04 kg CO_2 per litre for JME, respectively. Not surprisingly, an increase in seed yields would reduce the amount of carbon produced by the production of both JCL oil and JME.

Making JCL Biodiesel Better

The economic, environmental and energy performance of JCL oil can be improved in many of ways. These include: optimizing the production process; selecting high-yield seed varieties and improving yields through genetic manipulation; developing and using machines for de-husking and fruit collection that would reduce the cost of seed production; developing additional high-value-added products – for example, JCL seed cake could be used to produce foodstuff and pesticides.

The major energy inputs for the production of JCL biodiesel are in two main places: the

The Carbon Balance of the Production of JCL Biodiesel

Annual seed yield (kg ha^{-1})	297	891	1485	2079	2673	3267	3861
CO_{2eq} of JCL oil (tonne ha^{-1})	14.11	55.88	97.64	139.41	181.17	222.94	264.70
CO_{2eq} of JME (tonne ha^{-1})	15.49	60.01	104.54	149.06	193.59	238.11	282.64

application of herbicides, insecticides, and chemical fertilizers; and the extraction and refining of oil. This means that one effective way to reduce energy use in the JBL biodiesel production process would be the application of 'low energy' green manures.

Another opportunity to significantly reduce energy use is offered by the fruit husks that are one of the co-products of the production of JCL biodiesel. If these husks are used as a substitute for coal, this helps reduce the overall energy use of the JCL biodiesel production process. Indeed, when the contribution of the use of fruit husks as fuel is taken into account, the use of JCL biodiesel produces carbon emission reductions worth 7,800 yuan per hectare.

Why JCL Biodiesel Should be Supported

Despite its lack of financial feasibility, the production and use of JCL biodiesel is a labour-intensive economic activity which could generate many job opportunities and increase farmers' incomes. The positive carbon balance and good energy production performance of JCL could also provide a way for the Chinese government to respond to climate change and energy security issues. These outcomes are consistent with the Chinese governments' plans and thus have important policy implications.

Overall, the study concludes that it would make sense to subsidise the production of JCL biodiesel if a seed yield higher than 2.46 tonnes per hectare can be achieved. The study highlights various subsidies that would help. For example, the researchers recommend that about 4.01 yuan per litre should be made available to producers of JME. This would allow them to purchase JCL seeds and to make enough revenue to break even on costs.

However, the study also recommends that subsidies and other economic mechanisms, such as tax exemptions, will not be enough to promote the industrialization of JCL biodiesel. The experience of other countries shows that other kinds of government support can play a critical role in the promotion of biofuels. One example of this kind of action would be to make the blending of biodiesel with conventional fuels mandatory.

More Research Necessary

However, before any policy instruments are adopted, their economic impacts should be assessed. For instance, mandatory blending would increase fuel prices at the filling station and the extra cost would be transferred to the consumer rather than billed to the taxpayer. Research will therefore be needed to work out how to mitigate such impacts.

More grants and funding should therefore be made available for research by government or private companies in the near future. China's renewable energy law has endorsed a special fiscal fund for renewable energy development. This special fiscal fund represents a very important source of money for the promotion of JCL biodiesel, but it still needs the relevant government agencies to make it available.

Looking to the future it is clear that the development of biodiesel is a complex challenge that will need to be carefully regulated. For example, the results obtained in this study are based on the assumption that JCL seeds are produced on marginal land. If other types of land are used to grow JCL then the environmental impact of the crop may increase. This means that sustainability standards and certification systems need to be put in place to ensure that JCL biodiesel is cultivated and processed in the right way.

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