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RURAL ADVANCEMENT FUND INTERNATIONAL

BIOTECHNOLOGY & VEGETABLE OILS
Focus on Oil Palm

ISSUE: Genetic modification of vegetable oils
CROP: All major vegetable oils will be affected; our report focuses on oil palm (Elaeis guineensis)
IMPACT: Production of oil palm is expected to increase dramatically; overproduction will depress world prices for other oils--displacing other oil producers, particularly in the Third World; widespread clonal production of oil palms will lead to greater genetic uniformity and vulnerability of crop.
PARTICIPANTS: Unilever (U.K.); IHRO (France); United Brands (USA) with Agrogene; Escagen (USA) with Sime Darby (Malaysia); Palm Oil Research Institute of Malaysia. (See box on companies--appendix)
ECONOMIC STAKES: Present world vegetable oil market is over $35 billion.
WHEN: Clonally propagated oil palms are now being field tested; a number of oils transformed through genetic engineering (rapeseed, soybean, sunflower) should be commercialized by the mid-1990s.

Introduction to Vegetable Oils

Worldwide, approximately 50 million metric tons (MT) of vegetable oils are produced annually, valued at approximately $35 billion.[1] The major edible oils are soybean, palm, sunflowerseed, rapeseed, coconut, palm kernel and cottonseed. The four leading vegetable oils, account for over 70% of world production.

PRODUCTION OF LEADING VEGETABLE OILS[2]
1986/87 in Million Metric Tons

Soybean	14.7
Palm	8.0
Rapeseed	6.7
Sunflower	6.5
All Other	14.1

□ P.O. Box 655 Pittsboro, North Carolina 27312, USA/919-542-1396
□ ~~RR1 (Beresford), Brandon, Manitoba, R7A 5Y1, CANADA/204-483-3955/TELEX # 7601055RAFIUC~~
□ RAFI/~~IIZ Wipplingerstr. 32, A-1010 Vienna, AUSTRIA/222/63-347-86-8/Telex #: 111010 TZST A ATT. IIZ/~~RAFI

In less than 20 years, worldwide vegetable oil production has doubled from about 25 million MT in 1969 to 50 million MT in 1987. Despite the increase in production, there is still a deficit of vegetable oils throughout most of the world.

Biotechnology offers the potential of radically transforming the production, marketing and end-use of vegetable oils. Over 19 companies based in Europe, the United States and Japan are now investing millions of dollars in research and development on the use of biotechnologies to modify and improve the properties of oils and fats (see appendix). Many universities and public research programs are pursuing similar goals. Current research employing both recombinant DNA technology (genetic engineering) and tissue culture techniques, takes two approaches: 1) genetic modification of oilseed plants to induce production of altered oils, and, 2) post-harvest modification of oils using enzymes or microbes.

According to Bioprocessing Technology the potential market for modified vegetable oils is $2.6 billion. There are many diverse goals for improving/modifying properties of vegetable oils. These include: nutritional properties (i.e. lowering saturated fat levels, reducing caloric content, etc.); improving processing characteristics (i.e. lowering costs of processing, improving shelf life; and conversion of low-cost oils into high value products. (About 70% of oils and fats are used in edible products, the remainder are used in production of lubricants, detergents and plastics.)

Soybeans, palm oil, rapeseed and sunflower are currently the major targets of biotechnology research because they are among the least expensive oils and the most easily manipulated using new biotechnologies. New biotechniques will be employed in oilseed varieties of soya, rape and sunflowers coming onto Northern markets in the early 1990's. Of these three crops - all widely (but not exclusively) grown in the North - sunflower yields are expected to rise 278% over their 1986 yields with both rapeseed and soyabeans trailing with gains of 189% and 176% respectively. With the exception of sunflowers in the USA and soybeans in Canada, however, the largest increases will take place in the South where yields in the three crops will either double or even triple[3].

This issue of RAFI Communique focuses on oil palm, the crop which many predict will capture the dominant position in the worldwide vegetable oil industry.

Oil Palm

Oil palm (Elaeis guineensis) is a perennial plant native to West Africa's equatorial rain forest belt. The oil palm produces two vegetable oils--palm oil and palm kernel oil. The former comes from the flesh of the fruit and the latter from the nut or kernel. When properly cultivated the oil palm produces higher yields per acre than any other oilseed crop, approximately 5.2 tons of oil per hectare annually.

> **Oil palm is so incredibly more efficient an oil producer than any other plant that it will ultimately, I think, make all other vegetable oi-producing plants obsolete. Imagine a plant that can make 3,000-4,000 lbs. of edible oil per acre per year, starting the third year after you plant it and going on for another 25 or 30 years. Very low cost producer. Right now Malaysia has a corner on the market. But it's being planted very rapidly in Indonesia and Brazil and in all the tropical countries. There's going to be an awful lot of palm oil available in the rather near future. And it's going to decrease the price of edible oil...I can assure you that it is the vegetable oil of the future.**
>
> **- Dr. Charles Bonner - California Institute of Technology[4]**

The rise of palm oil as one of the world's leading vegetable oils has been spectacular. Even without applications of new biotechnologies, palm oil is expected to gain an even greater share of the worldwide vegetable oil market. In 1980, palm oil accounted for only 9% of the worldwide vegetable oil markets. After 1987/88, experts predict we will see "an unprecedented increase in world palm oil production," due largely to massive plantings in Indonesia (where up to 1.7 million hectares are to be planted).[5] By 1995, palm oil is expected to surpass soybean oil as the world's leading vegetable oil--capturing 21% of the total market. According to Oil World magazine, by the year 2000, mature palm oil area is predicted to reach 5 million hectares and produce 18 million MT of oil, compared with 2.4 million hectares and 7.5 million MT in 1986.[6]

In the past decade, Malaysian palm oil exports increased over two and one-half times. Nearly half of the world's increase in edible oil trade over the past 5 years is due to increased exports of Malaysian palm oil.[7] Malaysia now accounts for 56% of worldwide production, and 90% of global exports.[8] The following chart illustrates the spectacular growth of palm oil in Malaysia.

MALAYSIAN PALM OIL PRODUCTION [9] -- in metric tons

	1970	----	431,000 MT
	1981/82	----	3,351,000 MT
	1986/87	----	4,600,000 MT
forecast	1987/88	----	4,800,000 MT
forecast	1995	----	5,600,000 MT
forecast	2000	----	10,000,000 MT

Biotechnology in the Improvement of Oil Palm

Laboratory techniques for clonal propagation of oil palms by tissue culture have been available for the past 10 years, but commercial-scale production has not yet been realized.

Using this technique, oil palm trees with unique oil composition or specific hybrid combinations can be produced in large quantities. Clonal propagation makes it possible to mass-produce genetically-uniform, high-yielding palm trees, by-passing the need for reproduction by seed. The basic technique involves the selection of superior, high-yielding oil palm varieties. Cuttings are grown on a simple growth medium in a test tube environment. Cells from these cuttings grow and develop into plantlets in response to certain nutrients and growth hormones.

The principle benefit of clonal propagation is that new varieties can be developed in less than half the time required by using conventional breeding alone. But this technique also carries the danger of leading to greater genetic uniformity and vulnerability of the oil palm crop. The basis for the entire oil palm industry in Southeast Asia is four West African palms that arrived in Indonesia around 1848[10]. By definition, large-scale plantings of geneticially uniform clones will do nothing to improve genetic diversity in Asia and could work to heighten the uniformity and risk for farmers in Africa.

Unilever Laboratories of England and the French IRHO (Institut de Recherches pour les Huiles et Oleagineux) in France initiated research on clonal propagation of oil palms in the late 1960s.

Because of its dominant position as a global producer and seller of oils and fats, the role of Unilever is particularly noteworthy. Over one-third of world trade in oils and fats is controlled by this multinational giant based in the United Kingdom and the Netherlands.[11] Unilever is one of the world's largest food corporations, and the largest buyer and seller of oils and fats. With 1986 annual sales of more than US$25 billion, the company ranks number seven on Fortune magazine's list of international enterprises.

As of 1985 (latest statistics available from Unilever sources), the company had approximately 66,000 hectares devoted to oil palm plantations in Colombia, Ghana, Zaire, Thailand, Cameroon and Malaysia.[12]

The first field planting of clonal palms was made in January, 1977 at Unilever's Pamol plantation in Malaysia. The company built facilities in England and Malaysia capable of mass-producing up to half a million clonal oil palms annually. In 1985, Unilever sold oil palm clones worth (British pounds) 1.4 million--and enthusiastically predicted that sales of clones would skyrocket to (British pounds) 17.5 million by 1995.[13] Plans were announced for the commercial-scale planting of cloned palms in Unilever's plantation in Colombia. In Brazil, Unilever's clones were sold for (US) $1 each, where at least six varieties were reportedly being tested in the Amazon region.[14]

The enthusiasm for mass-marketing and commercial-scale plantings of oil palm clones was suddenly dampened in 1986 when Unilever disclosed that experimental plantings in four Malaysian estates (cloned trees planted in 1983) began producing abnormal flowers and fruits. According to Unilever senior scientist, Dr. L.H. Jones:

> **"Field tests on clones produced in the lab went well, but when we went from lab to scale-up, problems occurred. It will be three to four years before we can check this generation to determine if the flowers are normal."**[15]

Unilever scientists claim that the cause of the abnormalities is not yet known, but it has resulted in a major setback for commercial-scale production of cloned oil palms. According to one industry journal, "no large scale plantings of oil palm clones are expected for at least 10 years in Southeast Asia", as a result of Unilevers problems.[16] Unilever has cut-back production of clones, and sales of cloned trees are now limited to within Unilever's plantation groups.[17]

It is impossible to know how widespread the problem is, or if Unilever and other companies have experienced abnormalities with clones sold and planted outside of Southeast Asia. The problem illustrates the kind of vulnerability and risk that Third World countries may suffer when used as a testing ground for new, but unproven technologies.

Despite the setback, it is certain that research on clonal propagation of oil palms will continue. Several major corporations, biotechnology companies, government institutions and plantation groups have initiated major research programs to commercialize the technique. The Palm Oil Research Institute of Malaysia (PORIM) a government sponsored institute which supports the nation's palm oil industry, is conducting its own tissue culture research in collaboration with plantation groups. Commercial plantings of cloned palms are foreseen for the 1990s.[18]

In the United States, a small biotechnology company, Escagen Inc., has an agreement with Malaysia's largest oil palm company, Sime Darby, on the development of clonal propagation techniques. After 6 years of research, the company is just getting to the point of field trials.[19]

In Kasragod, India, the Central Plantation Crop Research Institute has reportedly developed its own technique for producing clonal plantlets of oil palm.[20]

In mid-1987, the United Fruit Company (a subsidiary of United Brands) entered into an agreement with Agrogene Plant Sciences, a small biotechnology based in Florida, to conduct research on clonal propagation of oil palms (see details below).[21]

Clonal propagation of oil palm for commercial-scale production is in its infancy. Experimental plantings are still the rule, and large-scale commercial harvests have not yet been realized. It is generally recognized that clonal propagation will increase yields by at least 30%. But according to Unilever scientists, "theoretically yields as high as 17 tonnes of oil per hectare per annum should be possible," a <u>greater than 200% increase over current yields in Malaysia of about 5 - 6 tonnes per hectare per annum</u>.[22]

Palm Oil Production in Latin America

Southeast Asia is by far the dominant palm oil producing area, but recent reports indicate that Central and South America represent an untapped region for large-scale oil palm production.

Palm oil production in Latin America has more than doubled since 1979, with Colombia, Ecuador and Costa Rica accounting for almost 80% of the region's total production. Growth of the region's palm oil production has already resulted in a decline of U.S. soybean exports to Colombia and Ecuador.[23] Production is based on large, capital-intensive plantations. Unilever and United Brands are two of the dominant interests in the area, and both are experimenting with clonally-propagated oil palms for large-scale commercial production.

Unilever's first oil palm plantation in South America, Unipalma de Los Llanos, was formed in 1981 and planting began in 1982. According to Unilever, this plantation underwent "the first commercial-scale planting of clonal oil palms in the Western Hemisphere."[24] Approximately 2,200 hectares in Colombia are now planted in cloned oil palms, and about 30% of Colombia's oil palm plantations are irrigated.[25]

United Brands is the world's largest producer and distributor of bananas. Because of the low growth potential in the mature banana market and the spread of the devestating black sigatoks disease in Central America, the company is now re-planting old banana estates with cacao and oil palm. United Brand's Compania Bananera de Costa Rica accounts for about 15,000 hectares of oil palm out of a total of 18,450 hectares under production in Costa Rica. As a result of new plantings, palm oil production is projected to increase sharply by the year 2000, to over 112,000 tons (a 300% increase in production over current levels).[26]

United Brands is also experimenting with the development of high-yielding, clonally-propagated oil palms for its new plantations. In mid-1987, the company entered into an agreement with Agrogene Plant Science, a small biotechnology company based in Florida (USA), to conduct research on clonal propagation of oil palms. Agrogene specializes in tissue culture techniques and has the capacity to clone several million new plants a year. According to Agrogene's president, Dr. John Burrows, the company is developing clonal material for United Brand's palm oil operations throughout Central America.

Ecuador, Latin America's second largest producer of palm oil, is reportedly enthusiastic about establishing oil palm as a major new crop, in an attempt to compensate for an obsolete rubber industry and low crude oil prices. The recent establishment of oil palm plantations in the Amazonian jungle region of Ecuador, where more than 20,000 hectares have been cleared, has sparked considerable controversy.

In 1986, the Federation of Indigenous Peoples of the Ecuadorian Amazon claimed that cultivation of oil palm in the region threatens the lives of 115,000 indigenous people living in the area. According to the indigenous leaders, "...we also have to face the threats of investors, national and international companies that are planning, with the help of the government, to plow the jungle under. They see us only as opposing progress, or as cheap labor for their plantations and agroindustry."[27] Ecuador already has 20,000 hectares of oil palm under cultivation (major estates are the Palmoriente and Palmeras plantations), and plans are underway to expand production.

Brazil is now a relatively small producer of palm oil, but there is tremendous potential for growth. According to the U.S. Department of Agriculture, "there is an estimated 50 million hectares, mostly in the Amazon region, that is considered ideal for oil palm cultivation."[28] The Brazilians are reportedly interested in developing programs for the use of vegetable oils as a substitute for diesel fuel.

The Socio-Economic Impact

Some would argue that increased production of palm oil will provide a source of much-needed vegetable oils to Third World countries where diets are deficient in oils and fats. The growth and expansion of the palm oil industry in Southeast Asia and Latin America may, however, do little to boost the agricultural economies of developing nations. In addition, traditional, less productive producers of palm oil and other vegetable oils throughout the Third World will find it increasingly difficult to compete with modern, high-technology estates.

The establishment of new oil palm estates is extremely capital intensive. According to Unilever, the cost of setting up a 10,000 hectare estate is approximately (US) $75 million.[29] Once established, cloned palms will require considerably greater management than traditional palms. On average, vegetatively-propagated plants also require six times greater chemical protection than seed-propagated plants. Thus, new clonally-propagated oil palms will be controlled primarily by large corporations and government estates, with little or no opportunity for small-scale producers and a greatly reduced need for harvest workers.

New oil palm varieties are designed to maintain plantation profitability despite the predictable drop in edible oil prices which will result from massive overproduction.[30] In addition to high yields and disease resistance, new clones are selected for uniform ripening, low stature and easily accessible fruit--qualities designed to reduce significantly harvesting costs and harvest workers.

Third World producers of competing vegetable oils (particularly higher-priced oils) are already being affected by the glut of low-priced palm oil on the world market. Industry experts predict that, as palm oil captures a larger share of the world market, demand for vegetable oils such as groundnut, coconut and cottonseed oil will continue to decline. By 1995, the market for many of these higher-priced oils will be "much smaller than they were in 1960."[31]

Countries like the Philippines, where coconuts are the most important export crop, will be especially hard-hit. In the Philippines, some 700,000 small farmers grow coconuts on plots averaging less than 5 hectares. Nearly one-third of the Filipino population is dependent on the coconut industry.[32] A worldwide glut of low-priced palm oil will undoubtedly depress prices of competing oils--and could cause severe displacement of Filipino coconut producers with a long-lasting impact on the Philippine economy.

The impact of high-yielding oil palms is not limited to Third World farmers. In 1987, Malaysian exports of palm oil exceeded total world exports of soybean oil--resulting in large stocks of U.S. soybeans and a loss of markets for American soybean farmers. The U.S. Soybean Association (ASA) retaliated by launching a full-scale offensive against palm oil and other so-called "tropical fats". The American soya industry claims that palm, palm kernel and coconut oil behave more like animal fats than vegetable oils. The ASA is now lobbying for laws requiring special labeling of products containing these oils, a strategy designed to scare health-conscious American consumers away from such products and curtail markets for imported vegetable oils.

The "tropical fats" battle is, at best, the first salvo in an escalating war between otherwise interchangeable agricultural raw materials. Industrialized countries have a long history of winning such wars. In response to the U.S. soya industry's attack on coconut oil, Philippine President Corazon Aquino stated, "Unless Western markets are disabused of the lies that are being spread by our competitors abroad, 16 million people stand to lose their livelihood."[33]

Conclusion

The application of tissue culture technology to the oil palm will have a profound affect on the future of vegetable oil producers, consumers and vegetable oil markets around the world. It is virtually impossible to predict the outcome, however, since competing vegetable oils are also subject to manipulation by biotechniques which will drastically alter their production, sales and end-use. In his keynote address before the 1987 World Conference on Biotechnology for the Fats and Oils Industry in Hamburg, West Germany, Dr. Paul K. Stumpf of the University of California made the following observation:

> **...a versatile oil crop could affect greatly the economy of an entire nation. The oil palm is the principal agronomic crop in Malaysia, Indonesia and some African countries. If a genetically designed rapeseed or soya seed could produce the same type of triglycerides as economically what is now produced by the oil palm, then the oil palm industry would collapse, and the palm oil producing countries would suffer. Conversely, if the oil palm industry would apply the same techniques to the oil palm that were used to alter rapeseed or soya, then the oil palm would become the prime source of vegetable oils.**[34]

A special feature on biotechnology and vegetable oils appearing in Bioprocessing Technology made this prediction about the future of international competition in modified oils and fats:

> **Both genetic and enzymatic modification of oils and fats will steal some of the market away from the higher priced oils currently on the market. Expect to see a drop in the market for these oils as the market for modified oils grows. This will affect international competition by giving developed nations ways to produce oils similar to those that are now only available from developing countries.**[35]

1988 Survey of Companies Involved in Modification of Oils and Fats Using Biotechnologies*

Agrogene Plant Science, Inc., Florida, USA -- (A subsidiary of University Genetics Co.) Developing clonally propagated oil palms for United Fruit Co. plantations in Central America.

Ajinomoto Co., Inc, Tokyo, Japan -- Using enzymatic processes to manipulate fatty acids.

Allelix Inc., Mississauga, Ont., Canada -- Genetically engineering rapeseed (canola).

Asahi Denka Kogyo, Tokyo, Japan -- Using enzymatic processes to produce cacao butter substitutes from palm oil.

Biotechnica International, Calgary, Alberta, Canada -- Genetic engineering of rapeseed (canola) and flax.

Calgene, Inc., Davis, CA, USA -- Has approx. one dozen agreements with other companies to use genetic engineering for development of oilseeds and other crops with specific traits.

Cetus Corp., Emeryville, CA, USA -- Using enzymes to modify oils and fats.

Continental Grain Co., New York, NY, USA -- Conti-Seed Division will collaborate with DNA Plant Technology Corp. to develop better edible oil-producing plants.

DNA Plant Technology Corp., Cinnaminson, NJ, USA -- Tissue culture technology to modify vegetable oil plants.

Du Pont, Wilmington, DE, USA -- Funding research at DNA Plant Technology Corp. to develop new varieties of canola.

Escagen, Inc., California, USA -- Developing clonally propagated oil palms for a Malaysian plantation group.

Fuji Oil Co., Ltd., Osaka, Japan -- Has patent on use of lipase to make cacao butter.

Genencor Inc., South San Francisco, CA, USA -- Protein engineering to modify oils and fats.

Gist Brocades N.V., Delft, Netherlands -- Genetic modification of oils and fats.

Henkel Research Corp., Santa Rosa, CA, USA -- U.S.-based research center for German company, developing microbes for oil and fat modification.

Lubrizol Enterprises, Inc., Wickliffe, OH, USA -- Modifying sunflower, rapeseed, and corn plants to upgrade oils. Collaborates with Sungene Technologies and others.

Monsanto Co., St. Louis, MO, USA -- Transformation and regeneration of rapeseed (canola).

Nippon Steel Corp., Tokyo, Japan -- Has agreement with Calgene for genetically engineered specialty oils.

Oleofina S.A., Brussels, Belgium -- (Subsidiary of Petrofina) Genetic modification of oils for industrial uses.

Sungene Technologies Corp., Palo Alto, CA, USA -- Tissue culture research on corn, soybean, rapeseed, sunflower, and sesame.

United Fruit Co., New York, NY, USA -- Subsidiary of United Brands, establishing oil palm plantations in Central America, funding clonal propagation research at Agrogene Plant Sciences, Inc.

Unilever, United Kingdom and Netherlands -- Producing cacao butter substitute semicommercially; studying genetic and enzymatic modification of oils and fats; pioneer in clonal propagation of oil palm.

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* This survey adapted, in part, from list appearing in Bioprocessing Technology, September, 1987, p. 5, entitled "Companies Looking at Oil or Fat Modification." Other sources include: "Biotechnology: A Young Industry with Potential" in Jounal of the American Oil Chemists Society, September, 1987, p. 1221- 1233; and information compiled by Rural Advancement Fund International.

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