Commercialization of Oil-Seed Biotechnology Economic Implications for Secondary Agricultural Areas

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Progress in commercialization of biotechnology in production of oil palm, rapeseed, and soybeans has been remarkable, and the supply of vegetable oils is likely to increase. Some of the new cultivars of the oil-bearing crops offer an opportunity to expand agricultural production in marginal agricultural areas, but many will cause land diversion to other purposes. The long-term changes in the location of production will depend on the biological nature of the crop (annual vs perennial) and the future changes in demand. Aging populations in developed countries will pay more attention to nutritional qualities of vegetable oils. An increased industrial use of vegetable oil may require breeding for oil characteristics that are useful to industry.

Marginal agricultural areas can improve their position when a newly developed technology is applied in the production of a commodity that is of marginal importance to primary agricultural regions, or when biological specificity is such that it can be applied particularly well on marginal lands. Present developments in breeding new cultivars of selected oil-bearing crops and their potential impact on the agricultural production in marginal agricultural regions deserve attention because rising demand and government policy can change the pattern of production location and flows in international trade.

Biotechnology application to oil-bearing crops. Oil palm, native to West Africa, was brought to Asia where it became a plantation crop in the early 1900's (1). In Malaysia, the oil palm breeding program started in 1922. By the early 1980's, Malaysia was the primary palm oil producer and exporter. Malaysia's share of the world fats and oil market increased from 2% in 1960 to 20% in 1986 (2), as the country expanded its production and exports by a factor of 10 between 1970 and 1986. The expansion was a result of the shift from rubber production after a price decrease in 1961 (attributed to the development of superior and lower cost substitutes [3]), and an attempt by the Malaysian government to develop alternative exports (4).

Between 1986 and 1990, the production of palm oil in Malaysia is planned to increase by 6.7% annually, with tissue culture propagated trees being a major contributor to this growth. The long term prospects suggest an even larger impact of tissue culture in propagating oil palms. Due to the perennial nature of palm oil production, output does not respond to short-term price fluctuations. Conversely, area seeded and supply of annual oil-seed crops, including soybeans, rapeseed, and sunflower, do respond to yearly price fluctuation. Subsequently, with the slowly expanding demand for oil and steadily increasing supplies of palm oil, producers of annual oil crops may be forced to assume the role of a residual supplier of vegetable oils. Increasing production of palm oil is expected to exert a downward pressure on the price of all vegetable oils.

Palm oil cultivars are the highest yielding oil-bearing crop, producing 4-6 tons of oil per hectare (5). In 1977, the first oil palms propagated through tissue culture were planted in Malaysia. Experiments were successful, indicating more stable yields, with some clones showing little effects of environment and less variation in vegetative characteristics than seedlings (6). Tissue culture applied in propagating oil palm is expected to increase the yield of palm oil by about 30% (7).

Although oil palm has the highest production potential of all the oil-bearing crops, breeding through tissue culture for higher yield does not always lead to positive results. Reports from Malaysia indicate that among palm oil plantations achieving productive stage, some have infertile flowers. The apparent reason for this is too large a dosage of hormones to the medium in which micropropagated palms were growing prior to transplanting. Some palms produced withered fruit, and experts estimate that it will take at least five years before the problem can be corrected.

Perhaps the fear of becoming a residual supplier, subject to the potentially volatile price movements and increased market risk, was among the motivating forces behind the resource commitment to propagation programs focusing on annual oil-bearing crops. Rapeseed is a major oil-seed crop of Canada, Europe, and other northern climes. For example, in 1983 Canada exported 52% of the 2.7 million tons of rapeseed output. Currently planted rapeseed cultivars are free of the erucic acid. The improvement in propagating techniques, including tissue culture, stimulated studies on the return to agricultural research on rapeseed breeding programs (8-10), and led to the experimental use of tissue culture in rapeseed propagation. The progress has been remarkable, and the first rapeseed cultivars developed through tissue culture are to be utilized in 1989. New cultivars are expected to result in higher yields with increased resistance to diseases. As the adoption of new cultivars spreads through Canada, Europe, and the Soviet Union, the supply of rapeseed will increase. Under competitive market conditions, the price of rapeseed oil is expected to decrease in response to the larger supply. Lower rapeseed prices will encourage its wider use and may decrease the market share of other oils, including soybean oil.

The progress in developing improved soybean cultivars (using biotechnology) is slower than that of palm oil or rapeseed in terms of immediate commercial applications. American, Swiss, West German, and French companies are working on developing soybeans that can tolerate larger doses of herbicides such as glyphosphate, atrazine, and metribuzin (11). The recent breakthrough was reported in obtaining a strain of rhizobia living in symbiosis with alfalfa that more efficiently fixes nitrogen. It is expected that a similar change in *R. japonicum*, associated with soybeans, is possible. Herbicide tolerance and

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improved rhizobia strains for soybeans are among the developments likely to be commercialized before cultivars with other characteristics become available. Among soybean cultivars assigned the highest subjective probabilities of being developed soon were cultivars with altered amino acid balance, resistant to insects, bacteria, viruses, and fungi, as well as cultivars with a higher protein content.

Lower soybean prices resulted in reallocation of production across the United States. Regions where soybean production expanded in response to the high prices of the 1970's reduced the area devoted to soybeans in the mid-1980's. An analysis of the trends in area seeded and production of soybeans showed that the importance of soybeans for the Southern states declined as the soybean price decreased (12). The rate of decrease in soybean acreage in the Southeastern and Delta states exceeded the rate for the United States as a whole. One of the reasons for the difference in trends is the inability to compete in a cost-effective way in soybean production by Southern producers with farmers in the North Central Region at the prevailing market price. In 1985, for example, the total economic cost per bushel of soybeans was $4.73 in Illinois and $6.98 in Georgia (13).

Soybean biotechnology commercialization in marginal areas—model results. The economic impact of developing new soybean cultivars through the use of biotechnology requires further analysis. Results of such an analysis will be helpful in anticipating the relative position of the marginal agricultural areas in U.S. agricultural production after the commercialization of biotechnology. The analysis of regional land allocation was based on the long-term equilibrium model (14). The specified model consisted of ten regional production submodels. The South consisted of four regions: Appalachia, Southeast, Delta and Southern Plains.

The model was used for the evaluation of economic impacts of five technologies. They included virus, bacteria, and insect resistance, herbicide tolerance, and improved rhizobia strains. It was assumed that those biotechnologies were developed and universally applied in the production of soybeans as well as corn, wheat, sorghum, and rice.

Solutions obtained for the five models (one for each biotechnology) provided information on the allocation of agricultural land in ten regions. The impact of the analyzed biotechnologies on the agricultural land use differs across regions. Under applied assumptions, the three southern regions will likely withdraw a considerable amount of land from soybean production (Table 1). In particular, soybean acreage will be largely reduced following the introduction of bacteria-resistant cultivars. According to the model solutions, herbicide-tolerant cultivars (given commercial use) will also cause a reduction in acreage planted, but smaller than bacteria-resistant cultivars. Insect-resistant cultivars will lead to land reallocation and smaller soybean plantings in the Southeast. The Southeast soybean production will be less negatively affected by the use of cultivars capable of symbiosis with new rhizobia strains. The Southeast may improve its competitive position following the adaptation of virus-resistant cultivars.

TABLE 1

Change in Area Planted to Soybeans in the Southern United States Following Commercialization of Selected Technologies

Technology	Region		
	Appalachia	Southeast	Delta
	1,000 acres		
Base allocation using current technology	6252	5467	9984
Reallocated acreage after adoption of cultivars:			
Virus resistant	0	+547	-521
Bacteria resistant	-1591	-2843	-8465
Insect resistant	0	-707	0
Herbicide tolerant	-51	-682	-7043
New rhizobia strain	-51	-682	0

DISCUSSION

Increasing consumer awareness of the type and composition of fat on health may become a factor in determining the future demand for soybean oil. Improved cultivars of rapeseed and soybeans contain less than 15% of saturated fat. Limiting consumption of saturated fat lowers the level of blood cholesterol and decreases the risk of heart disease. In addition, soybean oil contains a high level of polyunsaturated fats (that reduce cholesterol levels) and is preferred for cooking. Palm oil is considered unhealthy because it contains more saturated fat than lard (51% of total fatty acids) and very little (10%) of polyunsaturated fats. Yet, because it is less expensive, food processors will use palm oil instead of soybean oil.

The importance of consumed fats in relation to health will likely increase in countries with increasing consumer education and large segments of older populations. The aging and affluent societies in developed countries will divert emphasis to the quality of fat consumed relative to unit cost. The increase in population aged 65 and over will be particularly high in Japan, Canada, Switzerland, West Germany, and France.

The search for new, non-food uses of agricultural commodities continues. Success in using soybean or palm oil as a substitute fuel for diesel engines depends on the relative prices. Other applications of vegetable oils in industry are being tested, but vegetable oils cannot be freely substituted in industrial uses. For example, from industry requirements the content of oleic, linoleic and linolenic acid is important. This situation can be changed by breeding oil-bearing crops focused not on yield or nutritional qualities, but on industrial applications (15).

Annual and perennial oilseed crops are subject to intensive development with emerging biotechnologies. New cultivars are entering production—e.g., oil palm—or will be available for farmers in the foreseeable future—e.g., rapeseed. Within the 1990's, the competition in the oilseed market is expected to intensify as the effects of new technology is reflected in larger supplies and will clash with domestic agricultural policies and a rather static market demand.

Economic interests of the United States, its distinctive regions, and other countries may be contradictory. The impact of biotechnology on regional production of soybeans and other major crops will often be negative for the marginal agricultural areas. The degree to which new technology will reallocate production will depend on yields of new cultivars, their fertilizer and pesticide requirements, as well as future relative prices of oil-bearing crops.

This paper focused on oilseed cultivars developed through the use of biotechnology and the consequences of their commercial application on changes in production, location, and trade. The analysis included oil palm, rapeseed, and soybeans. Further study is needed to evaluate the impact of developments in other oilseed crops, in order to provide additional estimates for informed decision-making.

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