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PYRETHRUM & BIOTECHNOLOGY

CROP: Pyrethrum flowers (Chrysanthemum cinerariaefolium), source of pyrethrins used as natural insecticide.

ISSUE: Bio-synthesis of pyrethrins in the laboratory using cell culture technology or enzymatic process.

IMPACT: If commercially successful, biosynthesis of pyrethrins will eliminate traditional production of pyrethrum flowers, a product valued at approximately (US) \$40 million annually. Over 200,000 small farmers involved in production.

COUNTRIES AFFECTED: Kenya, Tanzania, Rwanda, Zaire, Ecuador.

COMPANIES INVOLVED: McLaughlin Gormley King Co. of Minneapolis, Minnesota, USA.

WHEN: Pyrethrins now being produced in the laboratory. Researchers have filed patents and the company will not release information about commercial prospects.

Pyrethrum is derived from the dried flower heads of Chrysanthemum cinerariaefolium, a daisy-like perennial herb. The flowers of C. cinerariaefolium contain six insecticidal compounds collectively called "pyrethrins". The pyrethrins are extracted from the dried, ground-up flowers, and are the basic ingredient in many insecticidal products.

Since pyrethrins are relatively harmless to humans and animals, and have low persistence in the environment, these insecticidal compounds are a valuable "natural" insecticide.

Pyrethrum flowers can be grown in both the tropics and temperate regions of the world. But since the crop is extremely labor intensive, virtually all commercial pyrethrum is produced in Third World countries. Major producers include: Kenya, Tanzania, Rwanda, Zaire, Ecuador (see map, page 4).

Because pyrethrum flowers depend on a period of chilling to stimulate bud initiation, pyrethrum is cultivated in tropical highland regions which provide the necessary low temperatures. The

crop is especially labor intensive because the pyrethrum flowers do not all bloom at the same time, making it unsuitable for mechanical harvesting.¹ Pyrethrum is grown mainly by small farmers, in areas where it is usually the only available cash crop.²

The United States is by far the largest importer and user of pyrethrum, accounting for one-third of pyrethrum entering world trade. In 1987, U.S. imports of pyrethrum were valued at \$12.2 million.³ Other major consumers are the United Kingdom, Italy and Japan.

Competition from Synthetics

Pyrethrum is an expensive insecticide, so it is not surprising that the chemical industry has attempted to develop synthetic equivalents. With the introduction of synthetic "pyrethroids" in the 1960s, the pyrethrum industry began to experience a gradual decline in worldwide demand. Pyrethroids are man-made insecticides that have a chemical composition which closely resembles that of pyrethrins. However, since none of the commercially available pyrethroids are exactly the same as pyrethrins in regard to their insecticidal efficacy, pyrethrum is still a unique and highly valued natural insecticide.

In fact, over the past three years (1986-88) the Kenyan pyrethrum industry enjoyed sharp production increases. According to Kenya's Ministry of Planning, pyrethrum demand in world markets was stronger "owing to a strong pressure from environmental groups in the western world for a reduction in pollutants from artificial products."⁴

With the development of biotechnology and the potential for biosynthesis of pyrethrins, a much more serious threat to pyrethrum markets now looms on the horizon.

Bio-synthesis of Pyrethrum

Scientists are now producing pyrethrins in the laboratory using plant tissue culture as a means of production. The McLaughlin Gormley King Co. of Minneapolis, Minnesota (USA), began funding research on the biosynthesis of pyrethrins at the University of Minnesota in the early 1980s. The company now supports pyrethrin research at St. John's University in New York, and at the University of Texas. McLaughlin Gormley King is a privately-owned company and one of the world's largest importers of pyrethrum.

Using germplasm obtained from Tanzania and Ecuador, scientists at the University of Minnesota Department of Pharmaceutical Cell Biology successfully produced pyrethrins in the laboratory using high-yielding tissue cultures.^{5 6} Until recently, however, the prospect for commercial production of

pyrethrins via tissue culture has been disappointing because of insufficient yields.

The McLaughlin Gormley King Co. (MGK) is reluctant to answer questions about current research, because according to the company, "researchers who have carried our work forward are in the process of preparing patents and articles for publication." According to MGK's president, William Gullickson, "We've moved beyond the cell culture route. We've identified the enzymes in the plant that are responsible for converting material into pyrethrins." Commercialization of a bio-pyrethrin product will depend on whether large quantities of pyrethrin can be economically produced in an artificial medium.

What Impact on Pyrethrum Producers?

Kenya and Tanzania are the two largest pyrethrum producing nations. In 1987, Kenya earned (US) \$11.7 million from pyrethrum exports. The Kenyan crop is produced by over 100,000 small farmers (95% of Kenya's pyrethrum is produced by small landholders with less than 20 hectares).

In 1986/87, Tanzanian exports of pyrethrum were valued at (US) \$2.06 million. It is mainland Tanzania's eighth ranking agricultural product, produced by many thousands of small farmers in high altitude regions of Iringa and Mbeya where opportunities for other types of cash crops are limited.

Production statistics and export earnings for minor pyrethrum producing countries such as Rwanda, Zaire, and Ecuador are difficult to find. RAFI conservatively estimates that 200,000 small farmers are involved in pyrethrum production worldwide. The annual crop is worth an estimated \$40 million.

Conclusion

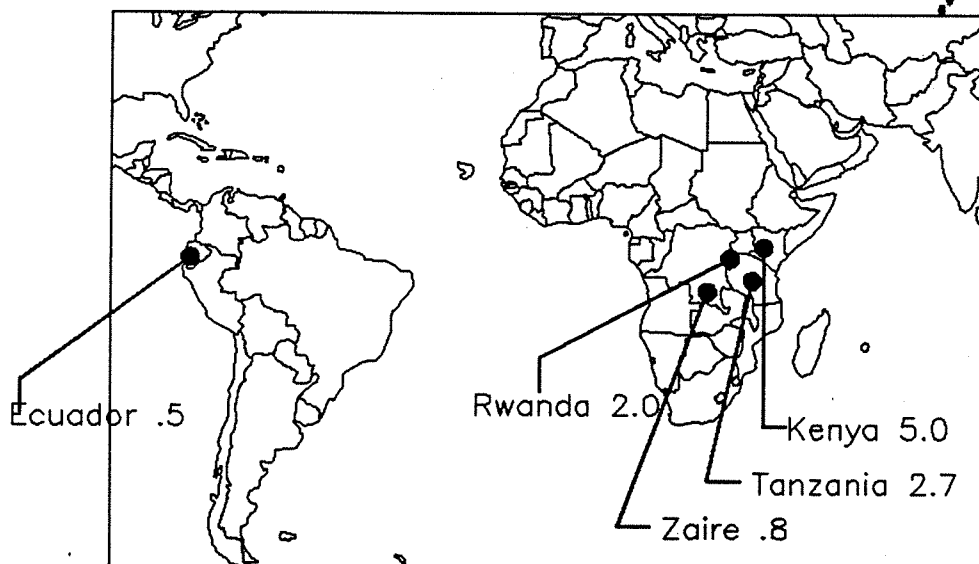
In terms of worldwide agricultural trade, export earnings from pyrethrum are small and insignificant. Yet over 200,000 small farmers in tropical highlands make their living growing this labor-intensive crop.

One of the world's largest importers of pyrethrum, McLaughlin Gormley King Co., is funding research on biosynthesis of pyrethrins. Using cell cultures and enzymatic processes as a means of production, pyrethrins are now being produced in the laboratory. If pyrethrins can be produced on a commercial scale at a price which is competitive with traditional pyrethrum extracts, this technology will displace pyrethrum exports on a massive scale. The production of pyrethrum would likely shift from East Africa to laboratories and factories in the industrialized world, eliminating hundreds of thousands of jobs related to traditional cultivation of the pyrethrum flower.

FOOTNOTES

- ¹ Dull, Rex E.T., Horticultural and Tropical Products Division, Commodity Programs, FAS/U.S. Department of Agriculture, Washington, D.C., USA.
- ² Contant, R.B., "Pyrethrum" in Evolution of Crop Plants, ed. by N. W. Simmonds, 1979, p. 33.
- ³ Dull, Rex. USDA.
- ⁴ Central Bureau of Statistics, Ministry of Planning and National Development, Republic of Kenya, Economic Survey, 1988, p.99.
- ⁵ Staba, E.J. and Zito, S.W., "The Production of Pyrethrins by *C. cinerariaefolium* (Trev) Bocc. in Primary and Secondary Metabolism of Plant Cell Cultures, Springer-Verlag, 1985, p.213.
- ⁶ Zito, S. et al. "Distribution of Pyrethrins..." in Planta Medica, Vol. 47, 1983, p. 205. Seed of selected high pyrethrin producing Tanzanian plants obtained from McLaughlin Gormley King Co.
- ⁷ Zieg, et al. "Selection of High Pyrethrin Producing Tissue Cultures" in Planta Medica, Vol. 48, 1983, p. 88.
- ⁸ Letter from William D. Gullickson, Jr., President of McLaughlin Gormley King Co. to Hope Shand, RAFI, December 12, 1988.
- ⁹ Letter from Graeme Donovan, Senior Agricultural Economist, Eastern Africa Division, World Bank, to Hope Shand, RAFI, February 8, 1988.
- ¹⁰ An estimated 9% of Kenya's 1.7 million smallholders grow the crop.
- ¹⁰ Ministry of Agriculture and Livestock Development, Annual Review of Pyrethrum, 1987, Marketing Development Bureau, Dar es Salaam, 1987, p.1.

**1987 World Production of Pyrethrum Flowers (Dry Basis)
By Principal Exporting Countries (million lbs.)**



Source: RAFI (statistics obtained from USDA)