II.

Abstracts of Workshop Papers

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TOBACCO LEAF PROTEIN

Pilot-scale technology that extracts high-quality protein from young tobacco leaves has been developed. Soluble proteins extracted from tobacco plants might be added to foods as nutritional supplements or for functional properties (e.g., gelling, thickening). Although not fully tested, they might have a specialized medicinal use as a pure protein source for kidney patients. Insoluble proteins might be suitable as a supplemental livestock feed. The leaf material left after protein extraction might be used in the manufacture of safer cigarettes with lower concentrations of toxic substances.

Several important constraints to the development of this technology make its future uncertain. Because a stigma is attached to tobacco by a large segment of society, there is a strong likelihood that food products developed from tobacco would not be readily accepted by the general public. Tobacco would face strong competition from alternate sources of protein. Before this technology could be economically viable, the residual deproteinized tobacco would have to be marketed successfully for the manufacture of smoking products, such as cigarettes. Significant flavor changes and associated characteristics of the deproteinized tobacco may not satisfy consumer tastes. Lastly, expanding the technology from the pilot scale to commercial scale will require the solution to certain technical and economic problems.

PROTEIN FROM TROPICAL PLANTS

The leaves of some 500 tropical plants have been screened by the U.S. Department of Agriculture (USDA) as potential sources of high-protein animal and human foods. Leaf protein fractionation for livestock feed is based on the principle that nitrogen-fixing plants contain higher levels of protein than ruminant animals can use, and nonruminants can assimilate only a portion of the total plant protein but cannot consume the volume of leaves necessary to meet their protein needs. The high-protein content of these plants allows partial removal of protein for nonruminant use and subsequent use of the remainder of the plant and its protein by ruminants. An appropriate combination of animals for the dual-use of leaf protein would be hogs and dairy cattle.

The plants with the greatest potential for commercial LPC (leaf protein concentrate) production are herbaceous nitrogen-fixers. Tropical grasses are naturally too low in nitrogen to be adequate sources of LPC. Fertilization with nitrogen increases the protein content, but the expense of commercial fertilizer is too great to make LPC production economical. Many tropical tree leaves contain toxic and antinutritional compounds which limit their use as livestock feed. Processing of the leaves might rid them of these harmful compounds, but the additional cost and technology requirements to do so might be prohibitive.

Work on alfalfa in the United States, Europe, and Japan has demonstrated the potential for dualwse of plant protein and has provided techniques and machinery that may be adapted to tropical plants. Although extraction and use of leaf protein in tropical regions seems promising, especially as livestock feed, a number of areas need additional research, including extraction methods, energy needs, acceptance of products, year-round vegetation supply, plant protein content, plant substances that adversely affect animal and human nutrition, environmental impacts, and cost. The feasibility of human use of LPC in tropical countries has been contested on grounds of health and practicality. Especially on small farms, protein probably can be better supplied through direct consumption of high-protein vegetables such as collards, mustard greens, amaranths, and the winged bean.

ENDOD IN COMBATING SCHISTOSOMIASIS

The berries of ended ***(Phytolacca dodecandra)***, the Ethiopian soapberry plant, after being dried, ground, and mixed with water, are used in Ethiopia and elsewhere as a detergent for washing clothes in rivers and streams. More importantly, within hours the solution can kill snails that carry schistosomiasis, a debilitating disease affecting an estimated 200 million to 300 million people and potentially infecting as many as 400 million others in many tropical and subtropical countries. The rapidly spreading disease poses a threat to large-scale irrigated agriculture and hydroelectric power development schemes in the tropics, many of which receive partial support from U.S. development assistance institutions.

A 5-year field study of endod's effectiveness against schistosomiasis in Ethiopia showed that after streams were treated with endod, the overall prevalence of the disease in *17,000* local people dropped from an initial 63 to 34 percent. In children of ages 1 to 6, the incidence of disease dropped from 50 to 7 percent. This and other tests indicate that ended, in combination with other drugs to treat already infected people, holds promise for controlling schistosomiasis and other snail-borne diseases.

MILKWEED: A POTENTIAL NEW CROP FOR THE WESTERN UNITED STATES

Arid / semiarid-land plants already are valuable sources of commercial products, including candelilla wax, jojoba oil, gum arabic, tragacanth gum, and natural rubber from guayule. However, many other arid and semiarid land plants represent largely untapped sources of chemicals for industrial feedstocks and other products. For example, pilot-scale research indicates that the showy milkweed ***(Asclepias dodecandra)*** contains many commercially exploitable chemicals. As with many plants, significantly higher value is obtained by fractionation of the plant material into component parts, any one of which alone would not economically justify milkweed as a crop. The development of milkweed as a commercial crop is contingent on solving certain agronomic and processing problems and on the development of markets for milkweed products.

Dryland agriculture using milkweed and other potential arid / semiarid crops could be ecologically and economically beneficial, especially in marginal areas now cultivated with traditional food and fiber crops. For example, milkweed might be preferable to existing crops in the western Great Plains where crop irrigation is causing overuse of the ground water. Developing new arid and semiarid crops also might expand agriculture to areas that now cannot be cultivated with existing crops. Before development of new crops is promoted on arid / semiarid lands generally considered to be ecologically fragile, cropping systems and other agronomic techniques must be available to minimize ecological disruption,

INSECT REPELLANTS, ATTRACTANTS, AND TOXICANTS FROM ARID/SMIARID LAND PLANTS

Many arid- and semiarid-land plants have been identified as potential commercial sources of natural insect attractants, repellents, and toxicants. Because these plant-derived chemicals are biodegradable, they might prove to be preferred alternatives to synthetic chemicals that persist in the environment long after application. Arid/semiarid plants may be potential new crops on lands that are marginal or unproductive for traditional food and fiber crops.

USDA screening has identified seven plants as particularly promising commercial sources of natural insecticides, insect repellents, or attractants. These are sweetflag ***(Acorus calamus),*** big sagebrush ***(Artemisia tridentata),*** neem ***(Azadirachta indica),*** Heliopsis (Heliopsis longipes), mamey apple ***(Mamea americana),*** sweet basil (Ocimum ***basilicum),*** and Mexican marigold ***(Tagetes minuta).*** Most of these plants have been used in other countries for various purposes on a local level but have not been developed on a large commercial scale.

Of the seven plants discussed, the neem tree seems to have the greatest potential as a commercial crop. Although all parts of the tree repel insects, the seeds are outstanding repellants and feeding deterrents for a wide range of household and agricultural pests. The rest of the tree—timber, bark, and leaves—has a variety of economic uses for construction and medicinal and hygenic applications. The tree grows well where many other plants present an erosion hazard or are unproductive, as in hot, dry climates and on shallow, stony, or sandy soils. Neem could be encouraged as a crop to further local economic development, especially in arid zone countries. Currently, there are neem plantations in India and in African, Latin American, and Caribbean countries. USDA has a program to develop neem as a commercial crop in Puerto Rico and the U.S. Virgin Islands.

COMMERCIAL PRODUCTS FROM MARINE PLANTS

Marine plants have evolved unique biochemical processes and structures in adapting to their chemical, physical, and biological environments. Although marine plant biochemistry is a relatively new field, research done to date reveals that marine algae represent potential sources of pharmaceuticals, agricultural chemicals, foods and food products, industrial chemical feedstocks, and other useful products. Despite this potential, little commercial development of marine plant products has occurred in the United States, with the exception of agar, carageenan, alginate, and beta-carotene for the food industry; chemicals for biomedical research; and glycerol for a variety of consumer products.

The success of tapping the rich potential of marine plants will depend on greater support of basic research in marine biochemistry, genetics, nutrition, reproduction, and mass culturing techniques. However, little Government funding for commercial development of marine extracts is available, and private sector activities in the field are limited, especially in pharmaceutical development. To ensure that basic research is translated into commercial application, a close link must be developed among Government, universities, and industry. The Sea Grant Program, funded by the Department of Commerce, provides such a link and demonstrates the effectiveness of such collaboration.

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ANTICANCER DRUGS FROM THE MADAGASCAR PERIWINKLE

The isolation, purification, and subsequent marketing of alkaloids from the Madagascar periwinkle ***(Catharanthus roseus)*** in the late 1950's and early 1960's instigated a resurgence of interest in plants as possible sources of anticancer drugs. Among the many periwinkle alkaloids showing anticancer activity, leurocristine* and vincaleukoblastine* * have reached the marketplace and are among the most effective cancer chemotherapy treatments available today. Vincristine, called a "miracle drug" because it was on the market less than 4 years after its discovery, shows a 50-percent-complete response rate in children with lymphocytic leukemia when administered alone and a 90-percent-complete response rate in combination therapy.

In addition to providing a valuable medicine for cancer patients, the periwinkle alkaloids have been very profitable to Ely Lilly, the pharmaceutical firm that developed the drugs. Despite the financial benefits resulting from research on the Madagascar periwinkle, Eli Lilly has shut down its plant screening program. It was the last U.S. pharmaceutical firm to have such a program. The U.S. Government has followed suit; the National Cancer Institute's program to test plants for antitumor activity was discontinued in 1981. Now that these two research programs have been discontinued, there are no major initiatives in the United States to search for anticancer drugs from plants.

The potential of plants as sources of new antitumor drugs has not been fully explored; the chemical compositions of only a small portion of the Earth's higher plant species have been chemically investigated. Despite the problems and high costs of developing new drugs, the success of the work on ***Catharanthus*** alkaloids illustrates that new drugs can be developed from plant resources, and at a profit, The reasons behind the current lack of research on antitumor drugs and the respective roles of the private and public sectors in such research should be examined.

*Known generically as vincristine.
**Known generically as vinblastine,

STRATEGIC AND ESSENTIAL INDUSTRIAL MATERIALS FROM PLANTS

The U.S. dependence on imports of essential industrial materials (including "stragetic" materials essential to national defense) and petroleum for industrial feedstocks and fuel could be reduced by domestic production of plants yielding these substances or their substitutes. In 1979, the United States imported an estimated $16.5 billion worth of petroleum for industrial feedstock and $6.5 billion worth of agriculturally produced industrial materials, of which some $3.5 billion was for newsprint and $1 billion was for chemicals extracted from plants. Domestic production of a portion of these materials could decrease the Nation's dependence on finite petroleum resources and increase U.S. dependence on agriculturally produced renewable resources.

Producing these materials in the United States could benefit farmers and manufacturers through crop and product diversification. The Nation could benefit from import substitution, reduced dependence on other countries for supplies of strategic and essential materials, and elimination of the need to stockpile strategic materials. Large-scale domestic production of industrial crops would require reallocation of large areas of land from other uses to these crops. Assessments of land availability and the ecologic and social impacts of altering land use should be considered. In addition, a great deal of research is needed on plant breeding and agronomy of potential industrial crops (e.g., guayule, crambe, jojoba, lesquerella, meadowfoam). Clearly, domestic production of industrial crops would be economically beneficial, but several social, economic, ecological, political, and foreign policy implications should be carefully examined.

INFORMATION USEFUL TO PLANT-DERIVED DRUG PROGRAMS

Plants play a major role in medicine. Plant-derived drugs represent approximately 25 percent of total prescriptions dispensed. The retail value in 1980 of U.S. prescription drugs containing active compounds from higher plants* is estimated to be at least $8 billion and over-the-counter drugs at some $1 billion. Because synthesis of almost all of the 50 pure-plant compounds used in prescriptions is not technically or economical feasible now, most of these compounds still are extracted from plants.

Despite the proven value of plant compounds as pharmaceutical ingredients, natural product development virtually has stopped and little work is being done on tissue-culturing and genetic engineering for production of plant-derived drugs. Drug development is relying increasingly on synthesis of new compounds. The reasons for the disinterest in plant-derived drugs may be lack of an assured plant supply, feelings that patent protection on natural products is insecure, or a sense that natural products research is unprofitable.

Plant drug development entails many steps, including plant selection and collection, bioassay procedures, isolation and identification of biologically active plant compounds, and clinical evaluation and marketing. Any shortcuts to systematize plant selection for screening and select appropriate bioassay procedures would decrease research time and expense and increase the chances of discovering marketable chemicals. Ten automated data bases that provide data on plant sciences, agriculture, and the chemistry and pharmacology of natural products can be used as screening aids for plant extracts work. One of these data bases, NAPRALERT, consisting of computerized files of research findings and published folklore information relevant to plant-derived drugs, can be extremely valuable to research on plant-derived drugs.

*Higher plants are those such as conifers and flowering plants, which possess a well-developed conducting system. Plants such as mosses, fungi, and algae are not part of this group.

USDA'S DATA BASE ON MINOR ECONOMIC PLANTS

Large numbers of plant species exist with commercial potential that remain undeveloped as crops. There is an overwhelming number of climatic, ecological, and anthropological variables associated with these plants. Since 1971, the USDA Economic Botany Laboratory has been developing a computerized information system on minor economic plant species. The system's files include information on agronomy, agroforestry, ecology, ethnomedicine, nutrition, pathology, and uses of several hundred plants. There is also a climate file with data for over 20,000 locations worldwide. A wide variety of questions can be answered by linking these files through a computer. For example, the system can help match new crops with environments in which they would be most successful, identify potential multipurpose crops for certain locations, determine the yield and nutritional value of a particular plant under given ecologic and agronomic conditions, help determine the potential spread of an introduced weed or pest, and identify sources of plants or specific germ plasm useful for crop improvement. These files are now off-line because of lack of funding. If maintained on-line and developed further, the system could be a valuable tool for new crop- and plant-product development.