PLANTS: THE POTENTIALS FOR EXTRACTING PROTEIN, MEDICINES, AND OTHER USEFUL CHEMICALS

(A Review of the OTA Workshop Papers)

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An Altenate Use for Tobacco Agriculture: Proteins for food Plus a Safer Smoking Material
by Samuel Wildman

The technology for extracting leaf protein has more important societal implications than the use of tobacco for protein. There are many reasons why tobacco leaf protein would be unacceptable in scarce resource situations such as in developing areas. The enormous amount of nitrogen fertilizer needed to produce tobacco protein is expensive and would be prohibitive in developing countries where imports of chemical fertilizers require the use of foreign exchange. A cost comparison of producing regular tobacco and producing tobacco for leaf protein on a per-acre basis is needed to judge the potential costs to the farmer. Because leaf attractiveness is not so important for tobacco grown for protein extraction, pesticide inputs would be less than in conventional production. The higher input costs accrued through four annual cuttings, each requiring fertilization, must be weighed against a higher value product. These tradeoffs must be examined in greater depth.

This technology is biased toward resource advantaged U.S. farmers because this kind of tobacco production is capital intensive in its use of nitrogen fertilizer and harvesting machinery. Resource disadvantaged farmers, particularly the small allotment holders in the rural South, would become even less competitive with the larger farmers, ultimately becoming more reliant on subsidies and less able to survive in a free market situation. Although the allotment system for tobacco may be a disadvantage to the ultimate rationality of farming in the South, by maintaining small farmers on the land, it has had important social benefits, A move to tobacco leaf protein may counteract that social welfare by shifting resources from less advantaged to more advantaged farmers.

The sociological problem of integrating an innovative structure of production into an ongoing technological system seems to be the biggest constraint faced by the tobacco protein project. The unique mechanism of physically and chemically fractionating the leaf and extracting Fraction 1 protein appears to be an important breakthrough that could be used for a variety of plants besides tobacco. Other plants may not have the established allotment structure and the established growers network of tobacco, but their products might be more readily accepted by the public. A nitrogen-fixing plant seems more appropriate because it would require lower fertilizer inputs.

Once the leaf protein is produced, there are marketing and market penetration problems that are difficult for small entrepreneurs to overcome. The medical market for leaf protein seems logical, but it is small, not particularly lucrative, and unlikely to support the large investment needed for protein extraction. The other products that the leaf protein might replace, such as egg albumin, are not in short supply. For example, the poultry industry is well developed. There would have to be a large price incentive for industries to seek a new product as a substitute to egg albumin in food processing. A substitution would require some production shifts in tooling or processing, and food industries seem particularly unwilling to make such shifts.

One argument of the large food manufacturers against the new product is that leaf protein from tobacco would prompt consumer groups to launch antinicotine campaigns, Possible problems arising with labeling—consumer acceptance of a product labeled as containing tobacco protein—may compound the difficulties facing tobacco leaf protein,

An alternative crop for this technology was not explored by Leaf Proteins, Inc. Soybeans or peanut leaves might be good substitutes in the South. Because they are nitrogen fixers, they require less fertilizer, therefore reducing crop costs and possibly increasing the profit per hectare. Initial profitability for the grower and producer of a vegetable protein product would have to be highly subsidized by State and Federal Governments. The commodity focus of U.S. agricultural development has limited the development of new crops, and subsidies to tobacco allotments inhibits the potential competitiveness of alternative crops.

The potential for local production must be determined when considering leaf protein as a dietary supplement for developing countries. As most developing countries have limited foreign exchange and are in a high debt squeeze, most protein for human consumption must be processed locally. The protein extraction process might be appropriate in developing countries where the State sector is active and will subsidize some of the initial start-up costs. In these countries, it is unlikely that tobacco would be the crop chosen for leaf protein extraction, however, except perhaps in the People's Republic of China, which already grows a great deal of tobacco.

In countries producing sugar, which has low current and expected world market prices, the sugarcane grinders and centrifuges might be modified for leaf protein extraction. However, the cost of machinery conversion probably would have to be borne by the State, and establishing distribution channels at first would have to be underwritten through grants and soft loans. It is doubtful that the protein could ever be self-supporting in poverty-stricken markets; it would have to be instigated as a social welfare measure.

The dehydrated alfalfa process provides an example of leaf protein extraction in the United States. It would be instructive to look at the problems of Pro-Xan processing and marketing.

If leaf protein were to be extracted from tobacco or other crops, plant breeders would have to reorient their breeding thrust. For example, if one were to use soybeans, one would stop breeding primarily for bean quality and also emphasize increased leaf mass and protein content. Bringing about a shift in breeder ideology might be a problem. Reputations in tobacco breeding sometimes have been made on a leaf appearance rather than foliage density.

The use of this new product would have to be linked closely to its manufacture. At first the process might be vertically integrated from contract growing to manufacturing, particularly if a new variety of tobacco or soybean were used. Once the new crop is established, contract growing probably would cease because it would be more profitable for the food manufacturer to buy on the open market.

In Third World countries, the use of tobacco instead of soybeans or another nitrogen-fixing food crop as a source of protein would have to be considered carefully. Alternatives to tobacco should be sought. Efforts are in progress to breed a tropical soybean that could be grown in areas where tobacco now is grown. The advantages of extracting protein from soybeans or peanuts instead of tobacco is that soybean and peanuts are nitrogen fixers, and the beans can be used directly as food or as a source of marketable oils. One criterion for choosing plants for protein extraction is that the plant or combination of plants provide leaves for a good portion of the year to avoid the costs of supporting idle machinery and the negative effects of a seasonal labor force.

For leaf protein to be a solution to Third World food problems, it would have to be produced locally at low cost. Available machinery should be adapted to avoid debts incurred for importing processing plants. Protein production would not generate foreign exchange because money from local sales cannot be used to repay most loans, and leaf protein produced in Third World countries probably would not be sold on an international market.

Loaf Protein Extraction From *Tropical Plants*

by Lehel Telek

Telek's discussion is aimed primarily at Third World countries. The process he reports is considerably simpler and cheaper than that suggested by Wildman. Telek's system of extraction deals with protein for animal fodder instead of the higher priced human food market. This process might be adapted to cooperatives, organized communities, or sugar refineries which, as protein extraction factories, could use their equipment and labor more economically year round.

This method of leaf protein processing is best suited for a relatively large, integrated operation of animals and plants. In the Third World, the ideal 10-cow/hundred-hog production unit is that of a wealthy farmer. Small peasant farmers have too few animals to apply the process effectively. Further, in most developing countries, few people eat animal protein, so the emphasis on fodder for larger animal herds will have little impact on the poor, landless worker or semiproletarianized peasant in most of the Third World. The process seems best adapted to centrally planned economies or cooperative production units.

Using a tractor as an energy source greatly limits the type of farmers for which such technology might be attractive. The price of tractors leaves few peasant farmers the option of this technology. In the Third World, as in the United States, large scale animal production now tends to be based on purchasing feed inputs rather than producing them on the farm.

Leaf protein extraction might encourage more integrated farming enterprises, which raise livestock and produce livestock feed on the same farm. This would require a high level of planning and coordination, and probably is most appropriate for either the public sector or highly capitalized, management-intensive private entities, such as companies producing beef for export, However, these entities would be more likely to supplement foreign exchange earnings and not directly increase protein availability to the poor in these countries.

The leaf protein technology described by Mr. Telek seems more adaptable to U.S. farming situations, particularly farms where rising costs of inputs encourage self sufficiency. This technology seems particularly appropriate for integrated dairy operations that might be expanded to include some hogs. The Cooperative Extension Service might work with small implement dealers to introduce this technology. The current crisis in farm incomes encourages adoption of such low-cost machinery.

There is a danger in depending on protein supplement programs to solve the problems of malnutrition in developing countries. These programs, particularly when imposed from the outside, often serve to only temporarily deal with the symptoms and not the causes of poverty. A community-controlled food supplement program that allows the community to produce protein and distribute it to children would be more successful in decreasing the number of malnourished children. More data on cost of production are needed. In addition, alternatives within the farming system should be examined to determine which ways of producing supplemental proteins—meat produced with LPC, LPC for human consumption, or alternative sources such as eggs from a community chicken-raising project—are more in keeping with both nutritional habits and production possibilities.

Molluscicidal and Other Economic Potentials Of Endod

by Aklilu Lemma

The development of ended is a good example of the potential of plants for community-controlled solutions to community problems. Research on the basic chemical properties of ended indicates its potential to supply a low technology molluscicide to control schistosomiasis. A similar community-based program could be envisioned in countries where malaria is a problem, since the ended berries have larvicidal properties effective against the mosquito.

Ended seems to grow wild under a variety of conditions. Cultivating ended and introducing it into new areas requires better knowledge of the plant's climate and soil requirements for optimal growth.

A community controlled program could be based on intensive ended cultivation by the public or private sector and treatment of infection sites with ended applied by the community. In a community-based project concerning public health problems, the public sector would have to bear the start up and research costs, and the community should be able to keep the project going through its local tax base and volunteer participation. The public sector would also have to be active in the educational campaign to link the community's actions to the results obtained, thus encouraging long-term local support and participation in the project. A monitoring system to gather statistics on the health impact of such a program, such as decreased infant death and disease incidence, would be beneficial. Unless communities perceive schistosomiasis as a problem and ended as a solution, continued community participation in possible future programs using ended as a molluscocide is unlikely.

Because research and start-up costs for community-based disease control programs are substantial, development assistance from more affluent countries may be needed. The crossover of benefits may be substantial so that the donor countries benefit at the same time as providing assistance. For example, mosquito control is a huge problem in many areas of the United States where DDT is outlawed. Ended could be an effective larvicide for mosquito control in such areas as rice fields in the central valleys of California where the mosquito is a consistent social irritant. Another possible application for ended is control of crayfish which dig holes in the dikes of rice paddies in California. Ended properly applied could reduce the costs of crayfish control and environmental problems of pesticide runoffs.

Ended research has progressed because of the combined efforts of the private and public sectors. Continued public sector support is necessary, The participation of the United States in ended research could both help alleviate Third World problems and have payoffs at home by providing inexpensive, environmentally satisfactory biocides.

The Role of the Alkaloids of Catharanthus Roseus . . . .

by Gordon Svoboda

Gordon Svoboda's remarkable presentation on the development of anti-cancer alkaloids from the Madagascar periwinkle should be considered in a larger context. A major pharmaceutical company, in this case Eli Lily, had to have available capital and be willing to risk it on such a "fishing expedition."

While the initial discovery was made at a university at public expense, product development was done by private enterprise. This link between basic university research and applied industry research seems to be an economically and socially beneficial model that should be encouraged. This case study appears to be unique, as no pharmaceutical company is doing botanic pharmaceutical research. It is important to understand why this research has been discontinued, especially since Dr. Svoboda's research apparently has been very profitable to Eli Lilly.

Has research shifted from botanical to chemical pharmaceuticals because chemical research can be carried out more rapidly than botanical research? Or, is industrial research funding being reduced in general, and, if so, what public efforts can counteract that situation? One important thing to look at is the potential linkage of university-based botanical pharmaceutical research and industry application. While the university should not be a tool of industry, it is important that top researchers continue screening, the results from which could be useful to pharmaceutical company scientists for subsequent product development research.

Part of this process involves an availability to both public and private sectors of past screening results to indicate which botanical are worth product development efforts. The screening program and linkage of this program to potential users require more study. The users, including private entities, must perceive that information on results of screening is available, and preferably computer accessible.

The difficulty synthesizing these anticancer drugs demonstrates that botanical and their biological sources have a continuing place in medicine. Despite the large number of leaves necessary to produce a small amount of the anticancer drug, a relatively small acreage is required for agricultural production. However, since growing probably would be done under contract arrangements, with production agreements between private farmers and pharmaceutical companies, it might provide price stability and a steady income for farmers who otherwise might depend on a single commodity. More information is needed on these kinds of agreements and variations in contract farming systems. When vertical integration is too intense and the market is oversaturated, as in the broiler industry, exploitation of the contract producer occurs, but when contracts are let simply to provide the input necessary for an established industry, a more equitable arrangement can be reached between the producer and the contractor.

Marine Plants: A Unique and Unexplored Resource

by William Fenical

Marine sources of food, pharmaceuticals, pesticides, and industrial chemical feedstocks have great commercial potential and may have much less negative impact than land-based botanical. Although research seems to have been on the taxonomy of marine organisms rather than their commercial potential, and only limited biochemical screening of marine plants for possible commercial products has been done, there are a number of interesting marine plant constituents that might be valuable,

The one marine plant industry that has developed in the United States, that of extracting agar, carageenan, and alginate from seaweeds, seems to be highly mechanized. It is difficult to conceive that this technology would be available to any but the largest multinational corporations. While certain algae cultivation is labor intensive in Japan, it is highly unlikely to be so in the United States. Thus, economic benefits derived from marine research would not necessarily accrue to small producers.

It appears that the public sector is not interested in or prepared to undertake marine-based pharmaceutical research or screening in the near future, but it is very important that these species be preserved until such time as they might prove useful. Insomuch as pollution can radically alter the nature of coastal habitats and their organisms, a critical government role would be to ensure that the oceans, particularly coastal areas, are kept as free as possible from pollutants. The recent deregulation of industrial waste dumping into major oceans may alter marine populations and ultimately decrease some sources of genetic variability. Perhaps we may decide not to do the expensive research and development necessary to develop marine products now, but we should not limit our future chances to do so by unregulated pollution of the oceans,

Insecticides, Insect Repellants, and Attractants From Arid/Semiarid Land Plants

by Martin Jacobson

This paper points out that many useful insecticides are available from plants. One wonders why, if nicotine is an effective insecticide as indicated by Jacobson, the work on tobacco does not consider nicotine as an insecticide as well as a source of protein and cigarette fiber.

The work at USDA, Beltsville, on isolating and identifying insect feeding deterrents in various weeds and crop plants might provide alternative crops for farmers if appropriate processing and marketing structures were developed. Putting these structures in place clearly would require government assistance, but ultimately might provide low cost, more environmentally safe insecticides that substantially could reduce the cost of crop production in the United States. These products also might have an impact in Third World countries if they can be produced with appropriate technology and little imported machinery. Some economies of scale probably would give a slight advantage to larger units of production over smaller peasant plots.

The work done by USDA at Beltsville in identifying potentially useful insecticidal plants must be taken one step further-to production. Private and public sector research to determine commerical feasibility and establish marketing structures is the next order of business.

Jacobson considers the neem tree to have the most potential as a source of insecticides. More agronomic information is needed to understand the neem growth cycle and the scale on which neem should be cultivated. The preliminary evidence suggests that neem could be a suitable cash crop for small family farms and that processing need not be done on a large scale. However, more work on scale of cultivation and process and economic feasibility must be done and questions on labor and product distribution answered. For example, how much local employment can neem seed processing generate? How much will this new industrial or semiindustrial development depend on established transportation networks to distribute the insecticide products? How large would a neem plantation have to be in order to be commercially feasible? How does the harvest cycle relate to other small farm labor demands?

The 5-year waiting time for the neem tree to bear fruit necessitates that any project introducing neem, especially projects in developing countries with small farmers, must ensure that sources of food and cash are available to the farm family for the first 5 years. The problem of motivating farm families to invest time, energy, and money in longterm payoff crops has to be examined when considering neem for commercial development in Third World countries.

Processing and cultivation have to be linked to markets from the beginning. The work already under way on neem suggests that an appropriate next step would be continued government support linked with small scale private industry for processing and marketing the product,

In the United States, public lands or communally held lands, such as those of the American Indians, seem prime targets for planting neem trees. However, labor requirements for harvest should be examined seriously. How is harvesting done, how many people must be involved, and how soon after ripening must the seeds be harvested and processed? The frost susceptibility of the neem tree might limit its use in Southwestern United States. The possibilities for selective breeding or simply selection for cold resistant species might be investigated. Land grant universities and small farmers could be involved in this screening procedure.

Other important questions that must be examined in regard to developing country production of the plants mentioned by Jacobson are those of labor requirements and distribution of labor among different family members. Labor intensity at certain times of the year may exclude small farmers, who often are limited by labor availability, especially at peak harvest times, from growing particular crops. Crops that are labor intensive, but have labor requirements more evenly distributed throughout the year, may be more appropriate for small farms. For example, basil might be a good cash crop for farm women. A marketing system would have to be developed and linked to industry, perhaps a small scale community-based industry specializing in oil from the basil plants.

Multiple product species, such as the mammyapple which yields an insecticide, wood, and fruit, have potential for increasing local self-sufficiency in developing countries. Systematic research on processing requirements of such multipurpose crops is needed. At this point, a good strategy might be for communities to work on developing an industry where there would be local supply of the raw inputs and local consumption of the outputs, It would be necessary to link community and industrial capital interested in investing in up-scaling the extraction procedure.

One of the important aspects in all of these crops is that apparently a substantial amount of plant biomass is required to yield a commercially viable amount of the product. This suggests that simple, decentralized plants, using village labor and village management which would increase the potential for community control and regional self-suffi-

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ciency, would be the best way to develop these products. That would require working with local communities at an early stage in the commercial development of these crops.

Chemicals From Arid/Semiarid Land hints: Whole Plant Use of Milkweeds

by Robert Adam

The use of arid and semiarid land plants as sources of industrial chemical products is appealing. The Jacobson and Adams papers illustrate that many of the common plants in arid and semiarid areas have potential for product development. The economic feasibility of cultivating these products on rangeland or on lands in other dryland crops or under irrigation, and subsequently developing the products, should be examined. Guayule and jojoba, which already are cultivated in certain areas of the United States, will be important models for arid/semiarid land plant development.

Developing cultivation techniques for arid and semiarid land plants and fulfilling labor requirements need attention. Certainly there is a great need for a dryland crop to replace irrigated agriculture in Oklahoma, Nebraska, and western Kansas. However, such crops will be adopted only when markets for them are established. Crops requiring a high level of processing, such as milkweed, will be less readily accepted than crops requiring minimum processing.

Milkweed development is such that large-scale production probably is needed to make it economically viable. Large amounts of milkweed are necessary to produce relatively small amounts of the more valuable products. The ability of a small, locally based industry to establish a milkweed stand and develop the variety of markets necessary to make milkweed financially viable is questionable. Scaling-up milkweed processing to make it commercially viable perhaps is the greatest constraint. Private enterprise may not be willing to take the risk, and capital available for small-scale venture activities, even in local communities, is scarce. Processing must be developed at the same time as milkweed is being produced. Timing the different aspects of production is crucial.

The toxicity of milkweed is a problem because the plants must be processed before use and the chance of spoilage during storage is increased. Milkweed's profitability and, thus, competitiveness with dryland wheat depends on inositol and pectin, two products that are difficult to extract and purify. Since these are high cost/low demand products, a balance must be found between the amount of milkweed needed to make the processing plant economically viable and the amount needed to supply, yet not flood, the inositol and pectin markets.

Introducing milkweed as a monoculture would tend to favor vertically integrated companies, large scale farmers, and rental land tenure arrangements. More information is needed on the use of milkweed as a livestock feed and its degree of competitiveness with feed corn, silage, and grain sorghum. Vertical integration from cultivation of milkweed to processing would be necessary and farmers have to have an assured market for milkweed.

A large amount of investment, probably from the public sector, will be necessary before milkweed can become a viable choice for U.S. farmers. The high degree of processing probably will preclude its use as a crop in Third World countries. Milkweed must be examined in comparison with alternative crops, particularly those crops requiring less processing, before large public investments are made. Unless simple machinery, fewer products, and a tight link between cultivation and processing can be developed simultaneously, it is doubtful that U.S. farmers will benefit from cultivating milkweed.

Strategic and Essential Industrial Materials From Plants- -Is and Uncertainties

by **Howard Tankersley** and Richard Wheaton

This paper raises important issues about the public sector's interaction with farmers producing raw materials and processors processing the materials for national and international markets. Domestic production of strategic materials, which are unavailable or in short supply, would be advantageous to the United States. Because no domestic industry to process these products exists, government support will be crucial. The U.S. Defense Department contract which has supported development of guayule as an alternative to natural rubber is an important example of government support for new crops.

For U.S. industry to be supplied with sufficient quantities of these-materials, 'farmers must be assured of a regular market for their products. Bankers and other lenders must be willing to give long-term credit to farmers investing in new crops that take a long time to establish. Government must work closely with local bankers to guarantee such long-term credit arrangements. Farmers may be motivated to change to strategic crops, particularly grain farmers in dryland areas of the United States, but current lending procedures and debts of the U.S. farm population suggest that without credit advantages such crop shifts are unlikely to take place.

The paper points to the necessity of subsidizing industries to develop these substitutes. However, subsidies for farmers, particularly as credit and applied research, will also be important, The high cost of price supports for the major commodities in the United States suggests the need to move quickly to subsidize alternative crops that ultimately may not need so large government inputs in the future.

Because nonexistent crops have no political power, there is little pressure for government involvement in them. Whereas the consumer would be the ultimate beneficiary of many of these alternative crops, consumers are not well organized pressure groups. It will be important to enlist the assistance of already organized groups whose welfare will be affected to gain political support for these projects. Commodity programs are the outcome of efforts by farmers and their organizations such as the Farm Bureau, Farmers Union, and the National Farmers' Organization. These organizations must be included in the early stage of crop substitution planning to assure that farmers' interests are protected, It might be useful to work with commodity groups, particularly those representing commodities grown in areas where new crops might be developed.

It would be interesting to look at the tax writeoffs available for planting jojoba to see their scope and to whom they apply. Generally the farm family does not profit from farming tax writeoffs and ultimately these kinds of tax subsidies encourage more absentee ownership.

It is important that U.S. foreign policy and U.S. domestic agricultural policy be consistent. Although farmers and USDA are moderately powerful in determining domestic policy, the State Department *seems* to be able to override their decisions when foreign policy concerns arise.

It takes a long time to develop a new crop, Farmers are disadvantaged because they absorb production risks and often are not paid for the year's production until the end of the growing cycle. Because new crops will take several years to become established, alternative sources of incomes for farmers during this initial period must be sought. Research on alternative crops should include work on intercropping or other mechanisms that can provide a regular income while the crops are being established,

The labor demands for crops such as guayule have not been discussed or evaluated in the Tankersley and Wheaton paper. It is important to see if the introduction of these alternative crops would create a new class of seasonal farm laborers or result in the creation of a smaller, year-round labor force. Alternative crops could help revitalize rural communities, particularly if the processing could be done locally. Will guayule rubber be processed in existing plants? Will intermediate processing take place near the point of production?

To assess alternative crops further, it is important to analyze the vested interests of each crop and its byproducts. For example, the importers of newsprint and paper, which kenaf would displace, may try to influence legislation. The kenaf experiment deserves close attention.

Commerically oriented research clearly is necessary and cooperative efforts between USDA, land grant university scientists, private development firms, and private industrial producers should be considered. Government support of research in all these sectors probably will be required. A dynamic capitalist system requires that the government can assume the risks of production in order to establish a profitable industry. Profit is correctly seen as belonging in the private sector, risk as belonging in the public sector.

It is vital that researchers work not only with farmers but with the end product producers to assure that breeding and selection meet the needs of production. This will help to provide a ready market for what farmers grow. A screening and breeding program for alternative crops would be very beneficial and could help strengthen ties between farm organizations and potential growers and industrial users. Clearly a coordinated government effort in appropriate agencies is needed for supporting R&D that may ultimately make these products commercially viable.

Historically, producing material has been less of a problem than processing the material. Industry seems more rigid than farmers in shifting products and techniques. Industry also seems less willing to take risks than farmers, who are accustomed to risks.

The shift in developing countries away from nonfood export crops might increase the availability of prime land for food production. These countries suffer from enormous balance of payment problems. A shift back to food, particularly if it could be coupled with the use of locally available pesticides and fertilizers in a mixed cropping system, might reduce dependence on foreign food imports, increase the foreign exchange balance, and increase the economic and political stability of many of these countries. However, it is important to realize that the international grain trade and the multinational corporations controlling it benefit greatly from this food dependence and from surplus grainstocks in the United States. In the grain trade, as much profit is made from shipping as from the sale of the actual products, and a great price fluctuation caused by a world market instead of a local market increases profits. The grain trade may be a potential opponent of shifting to multiple crops and increasing self-sufficiency, both in the United States and Third World countries.

A shift to food production in Third World countries often benefits small farmers, and might result ultimately in income redistribution both in rural and urban areas. Such a shift would decrease government's desires to subsidize cheap food because soft credit on food imports would no longer provide an artificial underwriting of food costs. That might lead to increased food costs in Third World countries, but those costs might be offset by increased food production and increased income, particularly to rural areas.

Prototype processing plant development should be undertaken as part of substitute crop development. However, such plants should be encouraged as joint government/private sector ventures, rather than simply government prototype plants. The investment of private industry will help increase their commitment to using the plants.

The variety of mechanisms available to the government to discourage imports and subsidize shifts in production needs to be fully examined. The wide variety of tax incentives and disincentives should be looked at before direct tariff protection or import negation is undertaken.

An arid plants experiment station might be called for to develop these products more fully. This experiment station should be staffed with more than agronomists and plant breeders and include people who might apply these products to industrial and nonindustrial uses based in the same area, Private firms might be encouraged to rotate personnel to these experiment stations/pilot plant areas in order to be fully involved in the development process.

The USDA Economic Botany Laboratory's Data Base on Minor Economic Plant Species

by James Duke

The data set of the USDA Economic Botany Laboratory could be valuable for any kind of experiment station breeding, selection or processing program. The case for a wide ranging, well documented data base is made strongly in this paper, and the amount of Federal dollars spent to support the program properly would be justified by the large savings made through information provided by the data base.

The funding for such a data system is important. This system should be on-line and linked to experiment stations throughout the United States. Further, informational linkages should be obtained with CGIAR (Consultative Group on International Agricultural Research) to avoid duplication of basic research and encourage greater use of existing information. A comprehensive, up-to-date, and flexible data base such as the one represented here is essential for organizing and making the vast amount of existing data available to users. One of the problems of the system is that it is little known. Knowledge, use, and support of this system must be expanded.

The potential value of data on ecological amplitudes of pests and diseases is very important for breeding programs. That file could save scientists thousands of hours of work. Millions of dollars for farmers and consumers could be saved if such data were put to use.

Information Gathering and Data Bases That Are Pertinent to the Development of Plant-

by Norman Farnsworth and William Loub

While Dr. Duke's paper deals with a wide variety of characteristics, Dr. Farnsworth's paper focused on drugs. The same arguments on cost effectiveness of data bases apply to Dr. Farnsworth's paper as apply to Dr. Duke's paper. The potential for avoiding costly mistakes by making both positive and negative research results available are increased by such data bases if they are on-line and available.

That data base would inform both processors and consumers, creating demands that farmers could then fulfill through shifting crop production. One of the crucial issues here for farmers is the difference between monoculture and mixed farming systems, The tendency in the United States has been towards monoculture. While this had certain elements of management and capital efficiency for farmers, it also increases farmers' risks through dependence on single commodities that tend to be overproduced in this country and worldwide. One of the important aspects of alternative crops is not that there will be a single miracle crop that will save the family farm, but that increased diversity available to American farmers will decrease the dependence of U.S. consumers on imported goods, particularly chemical products that will result both in lowered prices and higher quality. This increased diversity for farmers will in turn help U.S. taxpayers by decreasing the bills currently incurred for subsidizing the basic few commodities that are the focus of most U.S. production research.

It is important to remember, however, that those commodities are the basis of U.S. agriculture as we know it today. Alternative crops that can either be alternated or intercropped with our current crops would be an asset. Industrially, looking at crops that can interdigitate with or complement these crops on an industrial basis would also be important. For example, the kinds of botanical pesticides and products that can be used to coat grain for storage and reduce grain storage loss as insecticides might be an important kind of crop to consider in areas of high grain production and storage.

Whereas the use of plants as chemicals seems to have a ready market, health needs are less often translated into products because often the sickest people, as the hungriest people in society, have less effective demand. One of the roles of the government sector is to try systematically to meet the needs of those that are disadvantaged in a variety of ways. An important example of the positive role of the state is pointed out by Dr. Farnsworth. Japan and West Germany are active in the botanical pharmaceutical area. The close link between the public and the private sector in this is crucial for understanding its success.

One of the other issues that has impact on plant development is that of patents and right restrictions affecting ability to make a profit. It is clear that from farmer to processor to marketer, if a profit cannot be made at each step, a new crop or a new product cannot be introduced, whatever its potential large-scale societal benefits.

For this project to be successful, a close partnership with industry must occur. Again, government must act to further that link without creating a monopoly that is disadvantageous to the consumer.

The potential of botanical based medicines seems very high, It is also diversified. There is no one crop that will provide all the answers. This fact alone implies a systematic basic research program that involves careful screening and careful analysis prior to the undertaking of any project. The data bases described by Drs. Duke and Farnsworth seem basic to this process. Research that is government supported must be part of building a cumulative, collective undertaking, even though each discovery of course is that of individual scientists. Individual scientists must be assured access to the data bases so that they can be then implemented in further development. It is crucial that such research be related to potential use and use be related to manufacture and marketing. Government has an important role in establishing and subsidizing such linkages.

Conclusions

1. Research on alternative uses of plants, if combined with applied research on processing and marketing, could be very beneficial for the North American farmer and U.S. taxpayer, and, if the processing were relatively simple, to Third World farm families as well. Such crops would increase the diversity and self-sufficiency of farms and nation-states.

2. Research and development will need strong government involvement, through tax incentives and direct subsidies. Direct subsidies are especially important if less advantaged farmers and firms are to become involved in developing these new crops and products. They should be included not only to encourage better distribution of the benefits of the enterprises but because such units are more likely to make more radical changes because of their relative precarious situation.

3. Labor requirements and location of processing plants need to be assessed carefully. Such diversified crops and industrial processes have a great potential for furthering rural development in the United States and community development in Third World countries. In both cases, local government must be involved. Federal help in making

these links might be the catalyst needed for such development to occur.

4. Educational programs to increase awareness of the potential of new crops should be carried out, perhaps through government supported seminars coordinated through the USDA cooperative extension service. Established interest groups need to be persuaded that new crops or products ultimately will benefit their constituents. Minority entities, such as Indian nations, are particularly important beneficiaries of arid land plant development and need to be included as participants in the development of an arid land plant program.

5. Research in this area should continue and be better coordinated. The data systems described need increased support and to be linked to ongoing scientific activity and industrial R&D efforts. Personnel and computer funds must be appropriated in this area. The land grant universities and the USDA should be incorporated early into this research network. Not only will this improve the quality of the research but will ensure that an established lobbying group has a stake in the program.

6. Coordination of government agencies—including the Food and Drug Administration, USDA, Department of Defense, Department of State, and others—is important for the full development of alternative crops. Liaisons should be formed with appropriate agencies.