ECONOMIC PERSPECTIVE OF INTRODUCTION OF NEW CROPS

(A Review of the OTA Workshop Papers)

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introduction

The commercial development of a new product from a new crop, a new product from a known crop, or a substitute for an established product requires that a system involving three major subsystems be established: production, processing/marketing, and consumption (PMC). Each of these subsystems has a number of functional components, all of which must be in place and operating viably for the system to function effectively,

Historically, work on new crops has concentrated first on production technology, with only a general, and often somewhat vague, vision of the structure and magnitude of demand. Obviously, technological aspects of crop production must be researched, but demand and consequent costs and financial returns are just as critical,

Demand analysis and quantification are difficult to deal with at early stages of product development because there is a lack of data. Early critical input into decisions about making additional R&D or commercial investments can be provided by information gathered from experiences in other countries, similar existing products, and production technology research which will begin to generate some cost component information.

A number of possible economic benefits must accrue at various levels of the PMC system for successful introduction of a new crop/product. Benefits must accrue at the farm level; the marketing/processing level; and, for the government to cooperate in policy and/or R&D resources, at the national economy level. Some possible benefits at these different levels are listed in table 1. Whether a crop becomes profitable or not depends on more than the quantification of economic payout. Figure 1* shows the components of PMC Systems, demonstrating the wide range of possible economic variables involved in a PMC System.

In the past when new crops became commercial, the development of the system relied primarily on entrepreneurship, risk capital, and time. If one looks at crops that have been introduced and subsequently commercially developed in the United States within the last 50 years, one finds that there were one or a few key individuals or institutions who were convinced that the crop had a future and did not give up; for example, it was Mr. A. E. Staley for soybeans (processing); a couple of seed companies for sunflower; USDA and Texas A&M Sorghum Breeders for grain sorghum; and a few California avocado (hobbyists) growers for avocado. These are what we might call "commodity champions. "

If new crop research were to follow a more integrated approach, carrying out economic analysis simultaneously with technology research and constraint identification and analysis, profitable crops could be expected to be introduced in less time and at less cost. Demand and profitability analysis for the entire system, not just cost of production and partial product analyses, are needed.

The three following possible types of prefeasibility economic determinations should be made prior to the prototype stage:

1. In the case of import substitution or an alternative crop for an existing product: Is the price of the end product increasing at or above the rate of inflation?
2. Does the product have a high income elasticity of demand—i.e., as consumers' incomes increase do they allocate increasing proportions to that product?
3. Is there self-perpetuating demand for a new type of product—e.g., health foods?

Figure 2, "PMC System Decision Matrix, " was developed in the NSF study on "Feasibility of Introducing New Crops" to assist in analyzing the technical, economic, and institutional (regulatory, policy, sociological, etc.) constraints on production, marketing (procurement, processing, distribution), and consumption of new crop products. The matrix provides an idea of the components involved in new crop development, which if analyzed would provide an indication of economic feasibility of the crop/product introduction.

The discipline of economics never has enough data to give unequivocal answers, and economic data are especially limited in the early stages of new crop R&D. One effective technique to get the best possible estimates not only of economic but also technical and institutional feasibility is a modified Delphi technique. The technique gathers fact and opinion from all knowledgeable people about a subject, gives values to the judgments, and eventually arrives at some consensus on the actual *situation* regarding the issue. By using the Delphi technique to gather information on the various components shown in figure 2, the stage and potential of a crop's commercial development can be identified.

Simulation is one of the more comprehensive eco-

Table 1.—Benefits That Have an Impact on Economic Feasibility of New Crop Introduction

A. Farm Producer Benefits

1. Risk reduction
2. Stress tolerance
3. Value per acre intensification
4. Use of marginal land consistent with environmental limitations
5. Market diversification
6. Improved use of family labor
7. Improved use of permanent hired labor
8. Lower capital input

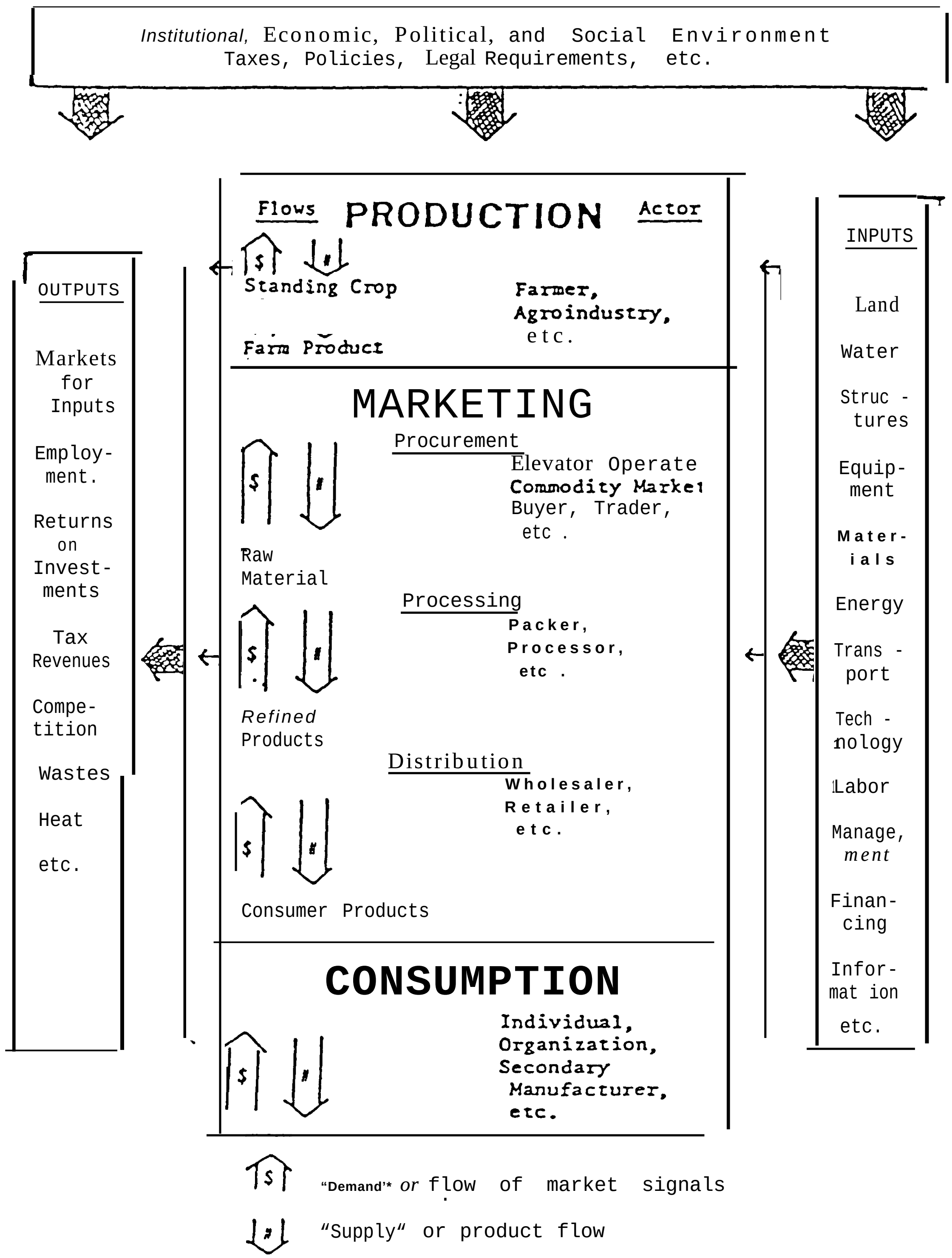
B. Marketing and Processing Benefits

1. High market demand potential
2. Existing installed processing capacity
3. Low processing system cost
4. Consistent demand
5. Product source diversification
6. Supply security enhancement

C. National Economy Benefits

1. Import substitution
2. Export market (foreign exchange earnings)
3. Productive use of otherwise marginal resources
4. Adaptable to natural resource conservation practices
5. Relatively low energy requirement for production and processing
6. Market diversification
7. High potential impact magnitude
8. Impact in areas with limited alternatives
9. Strategic or essential supply security (risk reduction)
10. Employment generation

Figure 1.—General PMC System[a]



[a]From NSF study

Figure 2.—The PMC System Decision Matrix[a]

Commodity Champi

	Component description	Physically possible	Economically feasible	Institutionally permissable	Subsystem
P 1	Land & water resources				PRODUCTION SUBSYSTEM
P 2	Production financing				
P 3	Pest control				
P 4	Seed availability				
P 5	Fertilizer needs				
P 6	Input procurement				
P 7	Farmers' risk taking				
P 8	Farm machinery needs				
P 9	Farm energy requirements				
P10	Input information				
P11	Gov't services & regulation				
P12	Ag research programs				
P13	Ag information programs				
P14	Crop organizations				
P15	Farm labor needs				
P16	Market info for farmers				
Ma1	Procurement resources				MARKETING SUBSYSTEM — procurement
Ma2	Dependable supply	I			
Ma3	Procurement financing.				
Ma4	Gov't service & regulation				
Ma5	Market intelligence				
Ma6	Transport & storage				
Mb1	Processing resources				MARKETING SUBSYSTEM — processing
Mb2	Processing equipment				
Mb3	Commodity institutions				
Mb4	Processing energy				
Mb5	Processing research				
Mb6	Processing info programs				
Mb7	Processing by-products				
Mb8	Managerial ability				
Mc1	Distribution resources				MARKETING SUBSYSTEM — distribution
Mc2	Distribution financing				
Mc3	Product market info				
Mc4	Product transportation			I	
Mc5	Market R & D				
Mc6	Gov't services & regulation				
C 1	Market penetration				CONSUMPTION SUBSYSTEM
C 2	Market size				
C 3	Consumer awareness				
C 4	Product versatility				

[a]From NSF study.

nomic analysis methodologies for determining feasibility of marketing/consumption components; farm budget analysis can be used effectively at the farm level to determine production feasibility.

Finally, to make effective use of the results of analyses and knowledge base for a particular crop, a formalized strategy for moving into the commercial production stage can be formulated using a technique called critical path programing. An example for kenaf from the NSF study is shown in figure 3.

Some additional observations on economic issues or constraints to new crop introduction are:

1. Lead time and development investments often are long and heavy, and risks are high because of the highly sophisticated nature of much new product development in the chemical, medical, pharmaceutical, and refined proteins areas. A concerted effort is needed to develop an effective partnership between government and the private sector to share in both the risks and the benefits.
2. The degree to which a new crop's development system is vertically integrated affects how well synchronized the establishment of the required subsystem components will be,
3. Many of the products that have been discussed at the workshop are subject to the "lumpy investment" syndrome in which large investments are needed to incorporate changes in production. These crops require much greater knowledge of the economic risks than crops for which investment increments follow a fairly smooth curve.
4. Interest groups and government should join together to form a "New Crops Council."
5. Existing food crops in developing countries are usually produced at no more than 30 to 40 percent of the potential of the land base. Food needs are more likely to be met by improving the ability to grow known crops than by introducing new crops,
6. Products derived from wild stands give commercial value to plants that previously had only local or no value. As demand increases, the cost of the raw product will increase. Once the demand for a product with a limited market and high price is satisfied, the product has near zero value. Production and demand can easily fall out of phase,

Following are the author's comments from an economics perspective on each of the papers presented at the workshop.

An Alternate Use for Tobacco Agriculture: Proteins for Food Plus a Safer Smoking Material

by Samuel Wildman

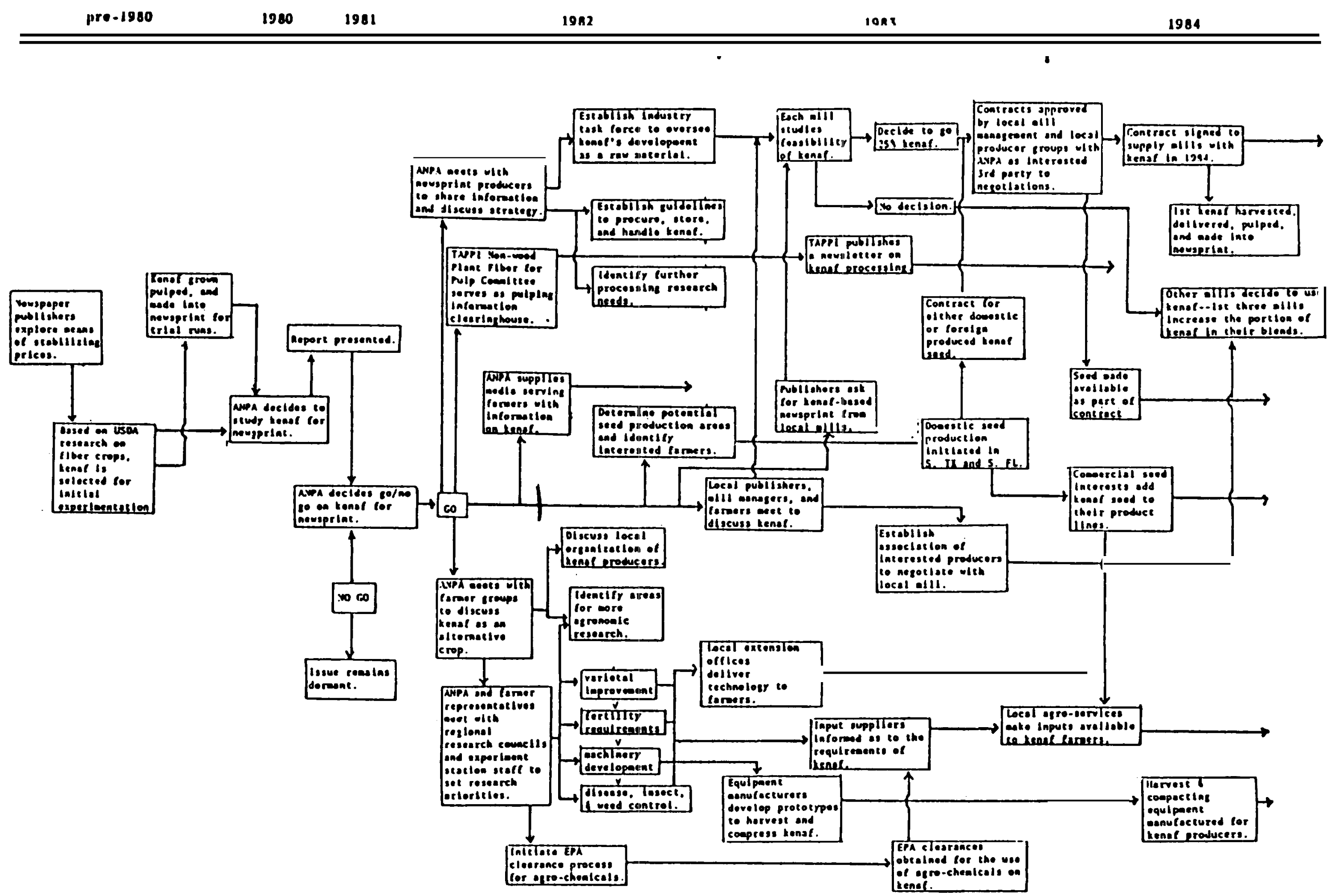
As in the case of many new crop development efforts, this presentation is long on technical process and short on economic feasibility. The shortage of protein in a global sense has to be considered in economic terms if it is to be solved. Demand varies according to the type of protein and whether it is for specialized use, animal use, or general human consumption. With specialized uses and animal use, the product must be able to compete with alternative products in price, availability, and ease of use, With human consumption, it also must compete with other products on the basis of consumer taste preference.

According to Wildman's paper, tobacco protein extracts have two major specialized uses: for specialized diet requirements and as a protein fortifier in the packaged foods industry. Although no information on market size is given, the demand for tobacco protein in specialized diets probably is quite limited. Processing requirements raise serious questions about the economic viability of protein extraction solely for this specialized product. Thus, economic feasibility probably depends on whether the other subproducts can compete in other protein markets.

Protein fortification in the general package foods industry is highly dependent upon final consumer demand. How much more will consumers pay for a protein fortified packaged food? Available evidence suggests that they will pay only marginally more because consumers of packaged foods generally have the purchasing power to get adequate protein from preferred sources, particularly meat. Thus, for this market, price becomes a prime element of economic feasibility. The paper does not provide adequate price information to evaluate the protein's competitiveness in this market, although the information provided suggests that its economic viability is somewhat doubtful, More economic information is needed before the technology's viability can be assessed.

Since the pricing of green sludge and green residue in the animal protein market depends largely on the price structure of the higher value products and the magnitude of the market, their competitive position is speculative. (The green residue would be used mainly for deproteinized cigarette tobac-

Figure 3.—A Crop Introduction Strategy for Kenaf*



*(Initiated and coordinated by consumers, i.e., newspaper publishers as represented by the American Newspaper Publishers Association (ANPA).) Goal: To produce 25% of domestic newsprint from pulped kenaf by 1990. From NSF study.

co, so one would assume it would be used **as** animal feed only when there is surplus.) If only limited amounts of these animal feed byproducts are available, compared with the massive market volume for their established competitors, it is unlikely that the feed industry would be willing to go to the trouble and expense of using minor and/or intermittent amounts of these new products.

In addition to the fortification of packaged foods, the other possible market for human consumption is as a protein supplement for populations that do not have the purchasing power to obtain adequate protein from preferred sources. This probably would have to be part of government programs. The history of attempts to market a protein additive for home prepared foods such as soups and stews as a means of increasing proteins in poor peoples' diets is abysmal.

Poor people on their own often will not buy protein supplements to add to their food, partly because being poor often is coincident with a low level of knowledge and commitment to nutritional needs. Even premixing protein in products bought by poor people has not had significant results. Witness attempts at lysine fortification of rice in Latin America, where housewives often pick out and throw away the slightly off-color lysine rice grain. Attempts in Latin America to encourage low income families to use the protein supplement INCAPARINA so far have been largely unsuccessful. Raising incomes may well be a more viable means of achieving nutritional goals.

In many developing countries, poor people suffer from calorie as well as protein shortages; often the small amount of protein consumed is converted to energy. The first nutritional requirement is to raise energy intake levels; otherwise much of the benefit of increasing protein intake is lost.

The following economic questions need to be answered:

1. In the United States, it is questionable whether the use of tobacco plants-for protein extracts will have significant impact on the net income per acre or the expansion of farmers' acreage in tobacco because after the protein has been extracted, tobacco processors would use the residual fibers to fulfill the demand for cigarette production.
2. Investment in commercial processing for tobacco protein is a "lumpy investment. " In order to accept the risk of investing in an expensive process change, good knowledge about the economics of the enterprise must be available.
3. The paper presents no economic information about competitiveness of tobacco compared with alternative feedstocks, except **to suggest** that **total** biomass per hectare is high compared with many alternative crops. That is not sufficient information to determine tobacco's competitiveness.

A commercial operation may be economically feasible, but the paper has not shown this, even at a prefeasibility level. A serious analysis of the entire PMC system for this crop/product is urgently needed before additional resources are invested in its development.

Loaf Protein Extraction From Tropical Plants

by Lehel Telek

Many of the same economic questions arise with this paper as with Wildman's. This paper also deals almost exclusively with technology and very little with demand, market, costs, and returns, a major weakness in most publicly and some privately funded new crop/product research. Original project design should include resources to do initial and subsequent periodic assessments of economic and institutional factors determining the feasibility of the entire PMC system upon which successful commercial development of the new crop/product depends. The additional cost for such economic/institutional analyses would be marginal, and the savings could be enormous.

Although this paper primarily addresses the animal protein market, human consumption also is contemplated. The comments made on Wildman's paper relating to human consumption are relevant to this paper as well. The LPE process explained in this paper appears to be much more feasible for animal protein production than the extraction process for tobacco. Because the protein extract from the LPE process would be used mainly as animal feed, it probably would be more competitive with alternative sources than with tobacco extracts.

Major weaknesses in the overall concept of processed leaf protein for animals in tropical areas need to be taken into account. There are a number of tropical crops that already are well-established and can be consumed directly by animals, even nonruminants. Although direct consumption may not permit the fine tuning of protein balance needed for optimum feed conversion ratios, this may not be so important in tropical areas as in the U.S. where conversion ratios are critical to profitability. In developing countries where opportunity cost of labor is low and conversion efficiency may be less critical, considerable improvement can be made in animal productivity through direct consumption of many existing, well-established crops. Marginal improvement in productivity of these crops and in their use in animal feeding could be achieved without introducing a processing technique requiring what would bean enormous capital investment in a developing country, as well as specialized knowledge. It seems unlikely that many developing countries will have either the institutional capacity or the economic capacity for large scale processed protein production and use for many years. These countries might be better advised to put scarce resources into improving animal feeding systems based on existing local products for direct consumption before new systems are introduced.

Again, having said this, there probably are areas of the tropical world that are ready for processed leaf protein. Puerto Rico may be one. Nevertheless, there is insufficient information to determine the economic feasibility of the system at present.

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

by Gordon Svoboda

Obviously, marketing alkaloids from the Madagascar periwinkle has been successful. If the divergence between general belief and actual fact about profitability of this cancer drug is as great as Svoboda suggests, some mechanism to counteract misinformation is needed to make venture capital aware of the profit potential of drugs from plants.

Some economic factors incident to this new crop/product area are:

1. The research process to arrive at the point reached for the Madagascar periwinkle is long and high risk. A partnership between government and private industry, where risks of "blind alleys" are shared, could stimulate more activity in the development of pharmaceuticals from plants.
2. Some public/private industrywide mechanism should exist for allocating resources to screening potentially valuable plants, including a standardized system for reviewing crops that merit further research. Resources for research are allocated in a somewhat random and discontinuous way at present.
3. Government regulation of the drug industry, while admittedly in the public interest, has raised the cost of product development and testing until the economic feasibility for many product markets is questionable. Economic efficiencies in the system can be achieved by streamlining compliance with and application of Government regulations, greater use of public resources for product R&D, and earlier attention to economic issues by the product developer.

Chemicals From Arid/Semiarid Land Plants: Whole Plant Use Of Milkweeds

by Robert Adams

This paper generally is responsive to the need for applying economic criteria to determine feasibility of new crop introduction. It points out the relative economic advantages of crops with the potential to produce several byproducts of economic value. It also highlights the advantages of looking at crops that do not compete in the same marketplace with domestic crops; some milkweed byproducts compete only with imported products. The paper also attempts to determine comparative advantage of milkweed production in semiarid areas now producing grain sorghum and wheat.

Because there is a lack of knowledge about processing costs for many of the extracts, their farm gate value is speculative and their economic feasibility cannot be predicted yet with any certainty. Nevertheless, the author is to be commended for making this early effort at determining economic feasibility at the production subsector level of the PMC system. Similar efforts, perhaps using the Delphi technique, need to be made for the marketing and consumption subsectors. Efforts at economic data improvement are imperative.

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

by Martin Jacobson

The paper provides intriguing information about seven crops that produce extracts with insecticidal properties. No economic information is provided for any except some yield and price information on neem tree products (oil and cake) in India. Apparently the author recognizes that unless some of the more valuable neem extracts can be efficiently produced and marketed, it is not an attractive income crop for a farmer who probably would earn very little from the harvested seed per tree per year.

Economic screening of the plants described is a necessary next step in determining which of them have economic potential. Applying the PMC systems analysis and using the Delphi technique to improve reliability of the data base could be quite helpful in making these economic choices.

Molluscicidal and Other Economic Potentials of Ended

by Aklilu Lemma

The information provided in this paper reflects the usual bias in new crops research; it emphasizes technological aspects although it recognizes the need for economic analysis.

This paper appropriately points out the potential for developing countries of foreign exchange savings (import substitution) by using domestically produced ended instead of importing chemical molluscicides to control schistosomiasis. Unfortunately, the paper does not provide cost and comparative price data to permit any but the most generalized assessment of economic potential.

A sufficient data base for *Ended* to permit a reasonably reliable PMC System analysis probably exists, Until a detailed analysis is done, the economic potential of *Ended* for the multiple uses proposed will remain largely speculative.

Marine Plants: A Unique and Unexplored Resource

by William Fenical

This paper summarizes some important commercial uses of marine algae for food or food supplements, fertilizer, pharmaceuticals, and in biomedical research. The paper also points out the vast untapped potential of marine plants as sources of biomass, pharmaceuticals, agricultural chemicals, food and food products, and industrial chemical feedstocks. Economic obstacles alluded to include high basic research costs of screening, bioassay, isolation, synthesis, etc.

Implications are that costs and risks of not being able to isolate commercially exploitable products are so great that only with appropriate joint public/private efforts can the potential in pharmaceutical use of marine plants be achieved. For new pharmaceutical uses, present slow progress likely will continue unless the United States makes a public policy decision to increase investments in this type of research.

Strategic and Essential Industrial Materials From Plants-Thesis and Uncertainties

by Howard C. Tankersley and 8. Richard Wheaton

This paper presents important preliminary strategic and economic criteria for pursuing national production potential for reducing dependence on foreign imports of a wide array of strategic and essential industrial materials.

In economic terms, the private sector has been unwilling to act on its own initiative, perhaps because it perceives the costs and risks of converting to national production as higher than continuing to import the products. Recent rapid increases in petroleum prices may have altered that outlook for the private sector, but public policy involvement probably is necessary to bring about a significant change of attitude of the private sector. Public policy decisions must relate to underwriting a part of R&D costs and assuring priority of U.S. produced products in the U.S. marketplace. It also may require some innovative arrangements between Government and the private sector concerning initial investments in industrial plant and equipment. Government policy actions for these strategic and essential products clearly are key factors in determining economic feasibility.

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

by Norman Farnsworth and William Loub;

and

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

by James Duke

Both of these data bases are important to furthering production and processing research in the new crops area. However, neither data base focuses on economic data.

Since economic data become outdated more rapidly than production, biological, and processing data, it is more difficult to deal with. However, a central economic data base could be quite helpful in encouraging both public and private sectors to invest in further development of promising new crops and products.

Again, until higher public sector priority is accorded to new crops/products development and reflected through increased R&D funding and appropriate policy actions, it is doubtful that there will be much change in the area of new crops development.

Conclusions

1. For a more coordinated and sustained focus on problems and prospects of new crops/products development, a representative private/public sector group needs to be established at the national level. A "New Crops Council" could: 1) be a clearinghouse for information, 2) provide guidance in establishing priorities, 3) enter into direct R&D, including initial commercial production, for new crops/products with sufficient technological, institutional, and economic promise, and 4) review areas of public policy that inhibit dynamic private involvement in the R&D process, and provide solutions to these.
2. The scientific community itself appears to have some attitudes that tend to dampen private and public sector enthusiasm for developing natural products derived from plants. The bias is toward synthetic organic chemicals and related fields. This reaches into the upper echelons of public and private sector management. If the many apparently sound economic, developmental, and societal arguments for more intense efforts at expanding our useful crops and plants base are valid, a well-coordinated educational process is in order. The public sector should take the initiative in such an educational effort.
3. Past and ongoing efforts at new crops development tend to focus on production and technological process factors, with little or no early attention to economic factors. Although there usually is some general economic rationale for looking at new crops and/or products, that rationale seldom is tested either empirically or with simulated information, A relatively reliable and low cost method for early analysis of economic potential, and identification of elements requiring in-depth economic analysis, was developed in the NSF study referred to earlier. All research projects on new crops should include resources to carry out a PMC Systems analysis at a very early stage, with required periodic updating of information and analysis. The Delphi technique can provide meaningful economic information at a very early stage in research on new crop production, processing, and use.

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