



Serving Human Needs: *Nuclear Technology for Sustainable Development*

Scientific Forum 18-19 September 2001

during the 45th Regular Session
of the IAEA General Conference

Austria Center Vienna

Programme and Extended Abstracts



International Atomic Energy Agency



International Atomic Energy Agency

Scientific Forum

Serving Human Needs: Nuclear Technology for Sustainable Development

18 - 19 September 2001

Conference Room C, Austria Center Vienna

Objective

The objective of this year's Scientific Forum is to increase Member States' awareness that technical co-operation in non-power applications can produce cost-effective solutions to high-priority problems of sustainable development.

Format

The first four sessions of the Scientific Forum will consist of presentations by leading experts drawing on practical examples of nuclear technology applications. Each session will be followed by a round-table discussion. In all sessions, Scientific Forum participants will be encouraged to engage in discussions with the speakers and panelists.

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Document Services, IAEA

PROGRAMME

Chairperson of the Forum: *V. S. Ramamurthy*, India

TUESDAY, 18 SEPTEMBER 2001

10.00 – 11.50 hours

Opening Session

- Opening statement by *M. ElBaradei*, Director General, IAEA
- Remarks by *V. S. Ramamurthy*, Forum Chairperson, India

Session 1: Science, Technology and Development: Interconnections

Session Chair: *S. Javed Burki*, Pakistan

Two prominent international development experts will provide their views on the role of science and technology transfer in development and how to manage such activities. A round-table discussion will follow the keynote presentations.

Keynote addresses:

J. Sachs, USA, will assess the strengths and shortcomings of current practices, and provide a vision of the future of science for development. This address will be in the form of a video presentation.

J. Vargas, Brazil, will focus on science and development from the perspective of developing countries.

Panelists:

Y. Seyyid Abdulai, OPEC Fund

W. Stumpf, South Africa

TUESDAY, 18 SEPTEMBER 2001

12.00 – 13.00 hours

Session 2: Promoting Food Security

Session Chair: *J. Turk*, USA

Isotopes and radiation can play key roles in enhancing food security by overcoming basic ecological constraints on agricultural productivity, and promoting more efficient use of land, water, and biological resources. Presentations and a round-table discussion among international experts and policy makers will highlight several examples.

Speakers:

J. Kabayo, Organization for African Unity, “Tsetse Fly and African Trypanosomosis: Towards a Lasting Solution”

P. Gómez Riera, Argentina, “The Sterile Insect Technique: Cost-effective Control of the Mediterranean Fruit Fly”

C. R. Bhatia, India, “Global Impact of Induced Mutation in Plant Breeding”

13.00 – 15.00 hours Break

15.00 – 16.20 hours

Session 2: Promoting Food Security (cont’d)

Session Chair: *J. Turk*, USA

Speaker:

M. Naqvi, Pakistan, “Utilization of Saline Water and Land: Reclaiming Lost Resources”

Panelists:

R. Mshangama, United Republic of Tanzania

B. Barnes, South Africa

M.A. Awan, Pakistan

J. Gallagher, USA

TUESDAY, 18 SEPTEMBER 2001

16.30 – 18.00 hours

Session 3: Managing Water Resources

Session Chair: *B. Attia*, Egypt

Managing scarce water resources wisely requires the kind of detailed understanding of aquifer dynamics that is sometimes only possible with the techniques of isotope hydrology. But water also must be of adequate quality to protect human health. Two presentations and a round-table discussion among international experts will focus on this increasingly important field.

Speakers:

M. Amha, Ethiopia, “Ethiopia’s National Strategy for Improving Water Resources Management”

B. N. Kabir, Bangladesh, “Understanding Arsenic Contamination of Groundwater in Bangladesh”

Panelists:

M. Dengo, United Nations

W. M. Edmunds, UK

I. Ahmad, Pakistan

WEDNESDAY, 19 SEPTEMBER 2001

10.00 – 13.00 hours

Session 4: Improving Human Health

Session Chair: *L. Pinillos Ashton*, Peru

The use of radiation in the diagnosis and treatment of disorders such as cancer is well known. Less familiar are crucial applications of isotopes and radiation for improving children's health through cost-effective interventions. Isotopes also are fundamental tools in the modern biotechnology laboratory's development of new vaccines and diagnostic reagents. Presentations by four distinguished speakers will be followed by a round-table discussion among leading experts.

Speakers:

W. Charoensiriwatana, Thailand, "Neonatal Screening for Treatable Congenital Disorders"

R. Uauy, Chile, "Stable Isotopes for Improving Human Nutrition"

R. Pardo Evans, Costa Rica, "Radiotherapy for Cancer Treatment: A Growing Priority for Developing Countries"

T. Yilma, USA, "Biotechnology for Development: Human and Animal Health Perspectives"

Panelists:

A. Aznarez, Uruguay

J. Amuasi, Ghana

B. Cummings, International Society for Radiation Oncology

A. Alwan, World Health Organization

S. Wade, Senegal

13.00 –15.00 hours Break

WEDNESDAY, 19 SEPTEMBER 2001

15.00 – 18.00 hours

Session 5: Panel: Matching Needs and Technologies: the Road Forward

Moderator: *M. Catley-Carlson*, Global Water Partnership

The Forum will conclude with a round-table discussion. Ms. Catley-Carlson will lead off the session with a summary of the Forum's deliberations.

Panelists:

B. Attia, Egypt

S. Javed Burki, Pakistan

L. Pinillos Ashton, Peru

J. Ritch, World Nuclear Association

J. Sachs, USA (via video conference at 16.30 hours)

R. Singh, India

J. Turk, USA

J. Vargas, Brazil

Closing Remarks

EXTENDED ABSTRACTS

The following summaries are based on information provided by the presenters. The views expressed remain the responsibility of the named authors and do not necessarily reflect those of the government of the Member State(s) or organization of the author. The IAEA cannot be held responsible for any material reproduced in this book.

MOBILIZING SCIENCE AND TECHNOLOGY TO ADDRESS THE PROBLEMS OF THE WORLD'S POOR

J. Sachs, Professor of International Trade, Harvard University, Cambridge, Massachusetts, USA
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Writing in *The Economist* of 15 February this year, Prof. Sachs raised several points that are relevant to any discussion of technical co-operation for sustainable development. He urges a stronger emphasis on the transfer of appropriate technology, and supports expanded roles for United Nations organizations in helping to solve the problems of the world's poorest countries. Here are some excerpts:

"A(n)...important challenge, as yet mainly unrecognised, is that of mobilising global science and technology to address the crises of public health, agricultural productivity, environmental degradation and demographic stress confronting these countries (i.e., the 42 so-called Highly Indebted Poor Countries — HIPCs, *ed.*) In part this will require that the wealthy governments enable the grossly underfinanced and underempowered United Nations institutions to become vibrant and active partners of human development."

"The conditions in many HIPCs are worsening dramatically, even as global science and technology create new surges of wealth and well-being in richer countries. The problem is that, for myriad reasons, the technological gains in wealthy countries do not readily diffuse to the poorest ones....Research and development of new technologies are overwhelmingly directed at rich-country problems. ***To the extent that the poor face distinctive challenges, science and technology must be directed purposefully towards them*** (emphasis added). In today's global set-up, that rarely happens....Currently, the international system fails to meet the technological needs of the world's poorest."

Prof. Sachs has been one of the few development economists to consistently remind us that most of the world's poor live under vastly different environmental conditions — mainly tropical climates with their often unique disease agents and agricultural factors — than most of the rich. He points out that sustainable development is not possible unless the underlying ecological constraints are removed or mitigated, yet most R&D is conducted by rich countries and focused on rich-country problems, not on tropical agriculture and medicine.

"If it were true that the poor were just like the rich but with less money, the global situation would be vastly easier than it is. As it happens, the poor live in different ecological zones, face different health conditions and must overcome agronomic limitations that are very different from those of rich countries. Those differences, indeed, are often a fundamental cause of persisting poverty....(For example)...populations are burdened by diseases such as malaria, hookworm, sleeping sickness and schistosomiasis, whose transmission generally depends on a warm climate...."

"...poor food productivity in the tropics is not merely a problem of poor social organization....Using current technologies and seed types, the tropics are inherently less productive in annual food crops. Most agriculture in the equatorial tropics is of very low productivity....Scientific advances again offer great hope. Biotechnology could mobilise genetic engineering to breed hardier plants that are more resistant to drought and less sensitive to pests....(and) there are dozens, or perhaps hundreds, of underused foodstuffs that are well adapted to the tropics and could be improved through directed biotechnology research. Such R&D is now all but lacking in the poorest countries."

In tackling all these problems, Prof. Sachs remains very sanguine both about the ability of science and technology to solve them, as well as about the role that the UN agencies can play in implementing those solutions.

"...rich and poor countries should direct their urgent attention to the mobilisation of science and technology for poor-country problems. The rich countries should understand that the IMF and World Bank are by themselves not equipped for that challenge. ***The specialised UN agencies have a great role to play, especially if they act as a bridge between the activities of advanced-country and developing-country scientific centres.***"

SCIENCE AND TECHNOLOGY IN A DEVELOPING COUNTRY: THE BRAZILIAN CASE

Jose Israel Vargas, Ambassador, Permanent Delegate of Brazil to UNESCO, Paris, France

This paper treats the development of science and technology in Brazil in a historical perspective within the Brazilian socio-economic context.

The development of natural and human resources and the build-up of the Brazilian economy that have taken place over the last few decades are best described against the background of the well known economic cycles involving sugar production, gold mining and coffee cultivation, all largely based on slave labor until late in the 19th century.

Brazilian industrialization has often been described as resulting from the adoption of an import substitution model. This paper claims that, alternatively, it may be described as a technology importation model.

The implementation of this scheme demanded the rapid development of human capital which, in Brazil, has followed an original approach. In fact, traditional university education only started in the 1930s, higher education having taken root only in previously isolated high quality technical schools, such as mining, electrical engineering, agricultural engineering and, of course, the traditional institutions for teaching medicine and law.

By the 1950s, largely under the influence of some outstanding scientists — mostly trained in the frontiers of nuclear sciences — the National Council of Research and the National Post-Graduate Training Programme were created. This has led, until now, to reasonable scientific, and to a lesser extent, technological development.

The recent globalization process — the new economy — has broken down barriers to international commerce and required in recent years greater efforts to disseminate basic general education and the fostering of advanced science and technology.

To this end, science and technology, along with research and development activities, have reached 1.35% and 0.9% of Brazil's GNP, respectively. Innovation as measured by patent applications has been modest. However, the technology balance has grown since the 1990s at a rate greater than 25% per year, reaching in 1999 US\$ 3 billion for imports and US\$ 1.35 billion for exports. In this context it is interesting to note that a recent UNDP study revealed an apparent paradox: while Brazil ranks 43rd in science and technology performance among the world's nations, it nevertheless ranks 27th among exporters of high-technology products.

Examples will be presented on the current progress in science and technology development in fields such as nuclear, computers, information, agricultural and health sciences, as well as on the implementation of novel legal approaches to induce innovation. The latter is seen as a precondition to strengthen the competitiveness of key industries, especially their entry into the rapidly evolving international market.

THE TSETSE FLY AND AFRICAN TRYPANOSOMOSIS: TOWARDS A LASTING SOLUTION

Dr. John P. Kabayo, Regional Coordinator, Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC), P.O.Box 200032, Addis Ababa, Ethiopia, E-mail: jkabayo@hotmail.com
for H.E. Ambassador Lawrence Agubuzu, Assistant Secretary General, Community Affairs Department, Organisation of African Unity, Addis Ababa, Ethiopia

Introduction

Tsetse flies carry and transmit infective microscopic parasitic microorganisms, called trypanosomes, which cause sleeping sickness in man and a similar devastating disease in domestic animals, known as nagana.

Over the past couple of centuries, periodic epidemic outbreaks of sleeping sickness wiped out entire communities in villages and settlements in various parts of Africa and caused massive depopulation of many areas. Many communities lost their domestic animals to trypanosomosis and gave up livestock production altogether; they concentrated on crop production, preferring to settle in elevated areas where they were comparatively safe from the diseases commonly found in low-lying areas. Other communities persisted with livestock production and settled in areas, e.g. savanna plains, where the limited vegetation cover was relatively tsetse-free. Over the years, this pattern of settlement, and the attendant separation of crop production from livestock production, has changed little. Significant mixed farming is only found in areas where tsetse and trypanosomosis no longer exist (see Figure). The uninhabited, undeveloped areas in between, often known as *Africa's green desert*, are usually home

Tsetse flies infest about 10 million square kilometer of fertile land spread across 37 countries.

The Root of Poverty - TseTse



Out of 165 Million cattle in Africa, 10 Million are found in the TseTse fly belt.

These are mostly low-producing breeds, which are maintained on high drug management regimes to keep trypanosomosis in check.

to wild life which not only provides a source of blood on which tsetse flies feed but also serves as the trypanosome reservoir. While wild animals are relatively tolerant of trypanosomosis, they act as a reservoir of the disease.

Socioeconomic Importance of Tsetse and Trypanosomosis

The tsetse fly is to a great extent responsible for the fact that, in most of Africa, horses and other beasts of burden are conspicuously absent. Similarly, the use of animal draught power in agriculture and transport, common in other parts of the world, has not been significantly developed. Largely because of trypanosomosis, and unlike anywhere else in the world, livestock production has usually been separated from agriculture. Except in tsetse-free areas, mixed farming has not been extensively practised in most of Africa. The phenomenon and cultural practice of nomadism is largely a result of having to play hide-and-seek with the tsetse fly, in an attempt to avoid the risk of exposing people and their livestock to the disease. It is difficult to exaggerate the consequences and effects on Africa's history and socioeconomic development of having to till the land by hand and trudge long distances on foot. The absence of mixed farming has tended to limit the availability of animal protein and manure, with severe consequences on the nutritional status of many African communities, and on the fertility and productivity of soils in many places.

The tsetse fly forced most of Africa to stock low-productivity animal breeds which, compared to exotic breeds, are relatively trypano-tolerant and are generally more capable of surviving infections of trypanosomosis. The disease and its threat caused depopulation of large areas of good pasture and agricultural land and led to overcrowding in the limited tsetse-free areas, creating a variety of problems ranging from competition for land to overgrazing, land degradation and a variety of ecological disruptions. Ironically, immense expanses of Africa's potential farming lands are uninhabited and undeveloped, because of the presence of the tsetse fly.

Tsetse flies occur in 37 countries of Africa in an area known as the tsetse fly belt, which covers about 10 million km² and stretches from Senegal in the north to South Africa in the south. This area, similar in size to the entire USA, is the most fertile land on the continent. There are about 165 million cattle on the African continent, of which only 10 million cattle are found within the tsetse fly belt. Tsetse-free South America, with about 70% of Africa's grazing area, stocks 465 million cattle.

To maintain the 10 million cattle of mostly unproductive breeds within the tsetse belt, the affected African countries consume 35 million doses of expensive trypanocidal drugs every year in futile efforts aimed at treating the disease, and engage in various activities to control the tsetse flies. The FAO estimates that every year Africa loses about \$ 1.2 billion in lost milk and beef production, and in costs connected with the efforts to treat or prevent the disease. Africa loses over 3 million domestic animals every year to causes directly traceable to tsetse-transmitted diseases. These losses can be as much as \$ 4.5 billion every year, if the losses in opportunities traceable to the presence and effect of the tsetse fly are considered. And these estimates do not include the cost of the effect of the disease on human health and productivity.

Elimination of tsetse flies will break the vicious circle of poverty and diminished productivity in Africa's rural areas

Communities in Africa's tsetse-free areas are able to stock higher productivity breeds of livestock and practise mixed farming. Contrary to the fears propagated by opponents of tsetse eradication, tsetse-free areas invariably show no signs of land degradation or other evidence of ecological disruption often predicted to accompany tsetse eradication. Stocking higher productivity breeds of livestock in these areas makes it unnecessary to maintain large herds. A consequence of mixed farming is the possibility to produce manure, improve soil fertility, leading to increased crop yields and at the same time improving the nutrition of the community.

Farmers in tsetse-free areas are not only relieved of the costs of treating or preventing trypanosomosis, but they also experience gains in increased productivity, especially if the possibility for the use of draught animals in agricultural production and transportation is considered. Coping with trypanosomosis in livestock accounts for over 90% of the expenses in animal husbandry care costs, and therefore the absence of tsetse flies represents a major saving indeed. Many communities whose areas have been rendered tsetse-free have witnessed the combination of savings and increased livestock production with consequent dramatic improvements in the quality of their lives and livelihood. No other development scheme or policy can generate the same evidence of success in guaranteeing sustainable development and alleviation of poverty in rural areas. The recent example of

Zanzibar is a vivid illustration of the proposition that tsetse eradication should be a primary component of every development policy in affected areas.

Success in Zanzibar

Tsetse eradication was declared in Zanzibar in September 1997, after a 3-year campaign that involved a combination of suppression of the tsetse population with conventional insecticide-based methods and the Sterile Insect Technique. Since then, reports of an economic turn-around for the island have attracted attention and confirmed the view that tsetse eradication has indeed been the missing key in Africa's rural development schemes. In the absence of tsetse flies on Zanzibar, farmers have introduced exotic breeds of livestock and have reported increases in milk production. This success has inspired countries in the rest of Africa to initiate programmes aimed at eradicating tsetse flies and eliminating the associated constraints to land use and agricultural productivity.

The Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC)

In July 2000, the African Heads of State and Government meeting at the OAU Summit in Lome, Togo, passed a Decision to eradicate tsetse flies from Africa. A Plan of Action, based on the proposal for a phased systematic elimination of isolated infestations of tsetse flies, was drawn up, and a campaign to generate the necessary action in each affected country is now being initiated.

There is confidence that once the threat of tsetse-transmitted diseases has finally been eliminated, development efforts aimed at fighting rural poverty will bear fruit. Consequently, emphasis should converge on the practical means and mechanisms of making tsetse eradication the initial objective of rural development policies and programmes.

THE STERILE INSECT TECHNIQUE: COST-EFFECTIVE CONTROL OF THE MEDITERRANEAN FRUIT FLY

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Fruit flies are one of the most important plant pests of the world, in terms of the number of fly species involved, the regions in which they are present, and the variety of hosts they infest. Six main genres are scattered all over the world. The A-B-Cs of fruit flies, in order of decreasing importance, are: *Anastrepha*, 183 species (spp.), 15 of economic importance (econ. imp.); *Bactrocera*, 486 spp., 39 of econ. imp.; and *Ceratitis*, 70 spp., 11 of econ. imp. Three other genres round out the picture: *Dacus*, 235 spp., 11 of econ. imp.; *Rhagoletis*, 62 spp., 6 of econ. imp.; and *Toxotrypana*, 7 spp., 1 of econ. imp.

Anastrepha is present in the Americas; *Bactrocera* in Asia and *Ceratitis* in Africa; *Dacus* in Africa and South East Asia, Australia and South Pacific Islands; and *Rhagoletis* in Chile, Peru, Eastern and Western USA, Europe and Asia (from Sweden to Kyrgyzstan and from Russia to France). There is an important species of *Bactrocera*, the Olive Fruit Fly (*B.oleae*), present in all olive-growing regions of Africa, Europe, the Middle East and Arab countries.

Seventy five species of plants of economic importance are infested by fruit flies. Among them are tropical fruits such as mango, guava, banana, papaya, fig, passion fruit and avocado; temperate fruits such as citrus (orange, grapefruit, tangerine, etc.), stone fruits (peach, apricot, cherry, etc.), nuts, grape, apple and pear; and vegetable crops such as cucurbits (squash, melon, watermelon), tomato, and eggplant. Fruit flies are present in 178 countries and islands; they are ubiquitous throughout the world between 45° North and 45° South latitude.

Twenty species of fruit flies are the most harmful because of the range of hosts they infest and the many countries affected. These 20 are subject to quarantine: trade in fresh produce is restricted to avoid the introduction of any one of these species.

The Mediterranean Fruit Fly, or simply Med Fly, (*Ceratitis capitata* Weid.) is the most harmful of all. It is present in 77 countries and infests 22 hosts of economic importance. From its origin in Central Africa, it has invaded northern Africa, Mediterranean Europe, the Middle East, all the Americas, and Australia. All the countries affected devote major efforts to eradicate this pest or greatly reduce its prevalence. The Med Fly has been eradicated from the USA (except Hawaii), Mexico, and Chile. Nevertheless, ongoing re-introductions occur and must be dealt with in Florida and California, Mexico and Chile.

Fruit flies, like any other pest, have been attacked with biocides at the farm level. Citrus is an instructive example. Citrus flowers and fruits twice a year, and various species and varieties provide year-round harvests. Biocides are typically applied to citrus every 10-15 days. Even so, the effectiveness is usually only 70-80%, due to uncontrolled neighboring farms, untreated hosts, problems with the spraying equipment, dose miscalculations, etc. Aerial applications of bait sprays to wider areas are more expensive, require a regional plan, and can represent a major impact to the environment. All means of application can leave pesticide residues in the fruit.

Trade in fresh fruits and vegetables is being liberalized on a world-wide basis as part of globalization. At the same time, local consumption of fresh products is increasing in the search for a healthier life. Pesticides are increasingly less acceptable in both the export trade and local markets. Newly adopted food safety and phytosanitary standards require the establishment of either low prevalence or entirely fruit fly-free areas. Environmental considerations reinforce the already favorable cost-benefit picture for the Sterile Insect Technique (SIT) as an alternative to controls that use chemicals alone.

The SIT has been in use since the 1950s. The aim of the technique is to disrupt the life cycle of the fly, mating the wild population with sterile flies reared at a "fly factory". Sterilization is accomplished by exposing insects to a specific dose of gamma radiation emitted by radioisotopes (cobalt-60 or cesium-137). Irradiation is a central and indispensable part of the total SIT process: every insect among millions produced each week must to be sterilized. No other method is available to achieve sterilization; chemosterilants, linear accelerators and the like have proven less cost-effective.

However, SIT is not a stand-alone technology. It is a valuable tool, but not the whole answer. To be effective, it must be integrated into a package together with non-nuclear techniques. These include a trapping system;

fly population monitoring; fruit sampling; laboratory analyses; data gathering and processing; mass rearing facilities; proper sterile fly handling and packing; aerial and/or terrestrial release protocols; cultural and chemical control of wild populations; quarantine protection; economic analyses; and public education.

Programs of fruit fly eradication and/or control using SIT are under way in California, Florida, Mexico, Central America, Peru, Chile, Argentina, Madeira, Israel, Jordan, South Africa, Thailand, Japan, Australia, and the Philippines. The majority target Medfly, with 21 labs and medium to large mass rearing facilities worldwide. But SIT is also being used against other fruit flies of economic importance including *A. ludens*, *A. obliqua*, *A. serpentina*, *A. suspensa*, *B. cucurbitae*, *B. Philippinensis*, and *B. tryoni*, involving facilities with production capacities from 11 to 100 million flies/week. Laboratory-scale rearing operations (less than 10 million/week), exist for *A. fraterculus*, *B. dorsalis*, *B. latifrons*, *B. oleae*, *B. zonata*, and *C. rosa*.

There is no doubt that the cost-benefit ratio favors SIT. Data from Argentina, the Middle East, California and Thailand illustrate this point. Costs are smaller than for chemical treatment, even if one disregards the hidden factors that the SIT affects only the target pest; does not disrupt beneficial fauna and bees; and can have a favorable impact on the environment. In California, for example, the Preventive Release Program (PRP) in the Los Angeles area releases 450 million sterile flies a week over an area of 2,489 sq-miles. A permanent Medfly infestation would provoke an estimated loss of 1,333 - 1,863 million US\$, due to increased pesticide use, quarantine compliance costs, increased costs of production and trade embargo, plus the environmental impact of increased pesticide use estimated at between 280,000 to 5,000,000 pounds annually. The average number of Medfly infestations in Los Angeles was 7.5/year before the PRP started (1987-94). This figure dropped to an average of 0.15/year after the PRP began, while annual control costs fell from US\$ 30 million before PRP to US\$ 14 million afterwards.

In Argentina, the total cost of the Medfly Program in Mendoza for the 2000-01 campaign is US\$ 5.5 million. Fly traps cover some 546,000 ha, which gives a direct cost of 10.07 US\$/ha. If we consider the actual area of 160,000 ha over which sterile flies are released, the cost increases to 34.36 US\$/ha. For comparison, in the major citrus growing area of Argentina, chemical applications consist of a bait of 5% sugar cane syrup (food), 3% nulture (attractant), and 0.1% malathion (insecticide). Applications are done on a weekly basis, with a mean of 12 applications per citrus variety over a period of 3 months. Varieties of orange, grapefruit and tangerine are grown all year round in a permanent rotation schedule. Direct costs of chemical applications--- including bait, labor, other inputs, and lease of machinery--- sum to US\$ 10-20/ha per application. The total cost for each variety reaches US\$ 120-240/ha.

A study in Israel and Jordan evaluated three alternatives: conventional malathion aerial bait spraying (C), the most common practice; SIT for eradication (E); and SIT for control (CO). Over a period of 14 years, annual costs were as follows. At year 3: C = US\$ 60 million, E = \$ 40 million and CO = \$ 40 million, respectively; at year 4: \$ 60, 30, and 70 million; and from years 8 to 14: \$ 60, 25 and 10 million.

The application of SIT for control rather than eradication sees the sterile fly as a biological insecticide. SIT is used in this way by the PRP in Los Angeles. It is applicable to area-wide control in many important fruit growing areas of the world. At a consultants meeting in Vienna in November, 1999, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture promulgated three such projects. One covers the citrus and tropical fruit growing regions of Mexico, Central America and Panama; it is now under way. A second project targets the world's largest citrus growing area, the Mercosur countries of South America. The third project focuses on the Mediterranean Basin (Southern Europe, Northern Africa and the Middle East), the second largest citrus growing region of the world.

The main objective of international organizations like FAO/IAEA should be to develop projects on a regional basis in order to meet the requirements of the area-wide concept. For their part, Member States should apply for and implement this kind of project in validation of the advice of the international organizations.

TABLE 1: STATISTICS OF FRUIT FLIES OF THE WORLD

GENERA OF FRUIT FLIES.TOTALNUMBER OF SPECIES (TNS) AND NUMBER OF SPECIES OF ECONOMIC IMPORTANCE (EI)

GENERA	TNS	EI
Anastrepha spp	183	15
Bactrocera spp	486	39
Ceratitidis spp	70	11
Dacus spp	235	11
Rhagoletis	62	6
Toxotrypana	7	1
TOTAL	1,043	83

MOST IMPORTANT SPECIES BY THE NUMBER OF HOSTS THEY INFEST

SPECIES	N°OF HOSTS
C.capitata	22
B.tryoni	11
B.dorsalis	9
B.cucurbitae	9
C.rosa	8
B.neohumeralis	8
A.fraterculus	8
B.zonata	7
A.suspensa	7

NUMBER OF FRUIT FLY SPECIES (NFFSP) ON THE SAME HOST

HOST	NFFSP
CITRUS	29
MANGO	29
GUAVA	24
PEACH	20
CUCURBITS	17
TROPICAL FRUITS	16
SQUASH	14
TOMATO	13
APPLE	12
AVOCADO	12
CUCUMBER	12
PAPAYA	11

There are at more than 75 plant species of economic importance hosts of fruit flies. The list includes Tropical fruits, pome fruits, stone fruits, grape, nuts, cucurbits, solanaceae, etc.

GEOGRAPHICAL DISPERSION OF FRUIT FLIES

SPECIES	N°COUNTRIES
C.capitata	77
A.obliqua	35
C.cucurbitae	28
B.oleae	27
D.ciliatus	25
A.fraterculus	22
R.cerasi	22
D.vertebratus	21
C. rosa	17
A.serpentina	16
A.striata	15
C.punctata	15

COUNTRIES WITH THE MOST IMPORTANT BIODIVERSITY (NATURAL AND / OR INTRODUCED) OF FRUIT FLIES OF ECONOMIC IMPORTANCE OVER 6 GENERA AND 83 SPECIES

COUNTRY	N° SPECIES
BRAZIL	14
INDONESIA	13
SOUTH AFRICA	13
THAILAND	13
ZIMBABWE	13
KENYA	12
TANZANIA	12
AUSTRALIA	10
INDIA	10
PAPUA/NEW GUINEA	10
PERU	10
VENEZUELA	10

Source:

THOMPSON, F. C. 1998. Fruit Fly Expert Identification System and Systematic Information Database.: A resource for identification of fruit flies and maggots, with information on their classification, distribution and documentation.

USDA. 1999. Fruit Fly Cooperative Control Program. Draft Environmental Impact Statement.

WHITE, I . M. and M. M .ELSON-HARRIS. 1992. Fruit Flies of Economic Significance: Their identification and bionomics.

TABLE 2: LABS AND MASS REARING FACILITIES OF THE WORLD BY SPECIES

COUNTRY	LOCATION	OPERATING SINCE	SPECIES	STRAIN	PRODUCTION MILIONS/WEEK	TOTAL MALE
PERU	PIURA	1999	A.fraterculus		1 to 2	
MEXICO	METAPA	1994	A.ludens		200-250	
USA	TEXAS	1986	A.ludens		18-40	
COSTA RICA	SAN JOSE	1960's	A.obliqua		less 1	
MEXICO	METAPA	1994	A.obliqua		50	
USA	TEXAS	1992	A.obliqua		less 1	
MEXICO	METAPA	1994	A.serpentina		5 to 10	
USA	TEXAS	1992	A.serpentina		less 1	
USA	FLORIDA	1987	A.suspensa		20-50	
JAPAN	OKINAWA	1973	B.cucurbitae		50-100	
USA	HAWAII	1956	B.cucurbitae		3	
THAILAND	PATHUMATANEE	1987	B.dorsalis		10	
USA	HAWAII	1956	B.dorsalis		1 to 5	
USA	HAWAII	1984-90	B.latifrons		less 1	
GREECE	ATENAS	1970's	B.olea		less 1	
PHILLIPINES	MANILA	1980's	B.philippinensis		1 to 20	
AUSTRALIA	PERTH	1989-90	B.tryoni	Bisexual	40	
AUSTRALIA	CAMPDEN	1996	B.tryoni	Bisexual	20	
PAKISTAN	TANDOJAM	1980's	B.zonata		1 to 3	
ARGENTINA	SAN JUAN	1982	C.capitata	Bisexual. San Juan	5 to 15	
ARGENTINA	MENDOZA	1992	C.capitata	SEIB 6 96	300	140
AUSTRALIA	PERTH	1978-85	C.capitata	Bisexual PERCVQ	10 to 15	
AUSTRALIA	PERTH	1999	C.capitata	VIENNA 7 99		10
AUSTRIA	SEIBERSDORF	1960's	C.capitata	Strain Collection	5 to 10	
BRAZIL	PIRACICABA	1997	C.capitata	Bisexual normal	less 1	
CHILE	ARICA	1993	C.capitata	SEIB 9 96		45
COSTA RICA	SAN JOSE	1960's	C.capitata	Bisexual local	5 to 10	
GREECE	CRETA	1993	C.capitata	SEIB 6 98/VIENNA 7 99	1 to 2/ 9	
GUATEMALA	PETAPA	1984	C.capitata	Bisexual Antigua	300-400	
GUATEMALA	EL PINO	1996	C.capitata	Bisexual Petapa/Antigua	200	
GUATEMALA	EL PINO	1996	C.capitata	VIENNA 4 94 TOLIMAN		450
GUATEMALA	EL PINO	1997	C.capitata	VIENNA 7 97		450
LEBANON	BEIRUT	1999	C.capitata	VIENNA 4 94 TOLIMAN		3
MEXICO	METAPA	1979	C.capitata	Bisexual Guatemala	400 - 500	
PERU	LA MOLINA	1960's	C.capitata	VIENNA 7 97		120
PORTUGAL	MADEIRA	1994	C.capitata	VIENNA 6 96		40
SOUTH AFRICA	STELLENBOSCH	1999	C.capitata	VIENNA 7 99		10
USA	HAWAII USDA	1991	C.capitata	Bisexual MAUI	200 - 300	
USA	HAWAII CDFA	1970's	C.capitata	Bisexual HILAB	70-150	
USA	HAWAII CDFA	1997-99	C.capitata	Bisexual HILAB	200 -300	
SOUTH AFRICA	STELLENBOSCH	1990's	C.rosa		1 to 3	

Source: Thematic Plan for Fruit Fly Control Using the Sterile Insect Technique. IAEA. Vienna. Austria. November 1999

TABLE 3: MOST IMPORTANT FRUIT FLIES FOR THE NUMBER OF HOSTS THEY INFEST; THE NUMBER OF COUNTRIES THEY ARE PRESENT IN AND/OR THERE IS A SIT TECHNIQUE

COMMON NAMES OF FRUIT FLIES (FF)	SCIENTIFIC NAMES OF FRUIT FLIES	TOTAL N° HOSTS	TOTAL N° COUNTRIES	MASS REARING FACILITIES			TOTAL FACILITIES
				LABS	11-100	MORE 100	
South American FF	A.fraterculus	8	22	1			1
Mexican FF	A.ludens	5	8		1	1	2
West Indies FF	A.obliqua	5	35	2	1		3
Sapote FF	A.serpentina	4	16	1	1		2
Guava FF	A.striata	5	21				0
Caribbean FF	A.suspensa	7	7		1		1
Oriental Melon FF	B.cucurbitae	9	28	1	1		2
Oriental FF	B.dorsalis	9	7	2			2
Solanum FF	B.latifrons	3	8	1			1
	B.neohumeralis	8	2				0
Olive FF	B.oleae	1	27	1			1
	B.philippinensis	3	1		1		1
Queensland FF	B.tryoni	11	1		2		2
Peach FF	B.zonata	7	7	1			1
Mediterranean FF	C.capitata	22	77	7	4	10	21
	C.punctata	2	15				0
Natal FF	C.rosa	8	17	1			1
Ethiopian FF	D.ciliatus	4	25				0
	D.vertebratus	4	21				
European Cherry FF	R.cerasi	1	22				0
	TOTAL	126	367	17	13	11	41

Note: Labs are those which produce less than 10 million flies a week; Medium between 11 and 100 million; Large more than 100 million flies/week

GLOBAL IMPACT OF INDUCED MUTATION IN PLANT BREEDING

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Introduction

Sudden, heritable changes in the genetic material, DNA, are known as mutations. Selection of naturally occurring mutations in wild, ancestral species helped humans in the domestication and further improvement of today's crop plants. Although Charles Darwin was unaware in 1859 of variation and mutations in living organisms, his theory of evolution by natural selection assumed variability. Much later, it was established that mutations are the source of biodiversity, and the driving force for evolution. Gregor Mendel in 1865 also used several mutants in his experiments with garden pea to formulate the laws of inheritance. The term mutation itself was used for the first time by Hugo de Vries in 1901 in his mutation theory.

Plant breeding based on the science of genetics, as practiced over the past 100 years, exploited the available genetic variability in the primary gene pool of crop plants, and sometimes in related species. This approach enlarged the yield potential of crops several fold. It also a) improved the stability of yield by incorporating resistance to various biotic and abiotic stresses; b) improved quality of the produce; and c) altered the adaptability of crop species, providing opportunities to grow new crops for food security outside their traditional range.

Genetically improved seed (or other planting material) is the most significant input for developing sustainable cropping systems for food security and economic growth. Half of the increased productivity of today's crop plants comes from genetic improvements. The other half is contributed by inputs and management practices.

Induced mutations

Exposing seeds and other plant tissues to radiation or chemical mutagens enhances the mutation rate and enlarges the overall genetic variability. In the past seventy years, and especially after the first FAO/IAEA meeting on the subject in 1964, plant breeders have made extensive use of induced genetic diversity to select for desirable characteristics. In principle, all genes can be mutated, provided appropriate screening methods are devised to select for the altered type. Mutants modifying morphological, physiological, and biochemical traits have been isolated and utilized in breeding programs. Visible traits that can be easily identified such as plant height, growth habit, flowering time, seed size, color, and composition, have been readily selected. Such mutants have either been developed directly as a new cultivar or utilized in cross breeding.

Impact of induced mutations

The Plant Breeding and Genetics Section of the Joint FAO/IAEA Division maintains a Mutant Variety Database (MVD) which lists more than 2250 cultivars of 175 species that have been officially released in sixty countries. Among these, 1700 are in the food crops cereals (1072), legumes (311), vegetables (66), and oil crops (59); the rest are industrial crops and ornamental plants¹. In fact, the MVD does not reveal the full usage of the induced variability because it does not include all the derivatives selected after cross breeding.

The impact of the new cultivars can only be estimated by the acreage in which they are grown. In the absence of well organized seed production in most developing countries, and given the prevalence of informal seed sales between farmers, it is very difficult to estimate the real spread of a given derivative. To take one important example, rice is the staple food for nearly half of the human population. More than 90% is grown in developing countries. 434 cultivars derived from induced mutants have been released in 28 countries, including

¹ Cultivation of ornamental plants, where climatic conditions provide a comparative advantage, generates cash flow for farmers, enhancing their access and entitlement to food.

China (117), Japan (46), India (31), Guyana (26), Ivory Coast (25) USA (23), and Vietnam (14). The data in Table I give an idea of the huge scope and impact of this success story.

Other major success stories are listed in Table II. Some unique mutants that have been isolated and used include those with alterations in fatty acid composition; host-pathogen and host-symbiont interactions; and response to day length. Economic benefits realized from some mutant varieties are given in Table III. Lastly, an example of estimated returns on investment in induced mutation research is presented (Table IV).

Mutant cultivars, both in developed and developing countries, have raised the land's productivity, improved quality, strengthened the production base, and contributed to food security and economic growth.

Outlook for the future

Continued growth in plant productivity will be necessary until the human population stabilizes. Even in a fully food-secure world, further improvements in crop plants will be required to meet the challenges of climatic changes, or for alternative uses of farm produce, for example as renewable starting material for industrial production.

New tools based on recombinant DNA techniques are being added rapidly to the plant breeder's "tool box". Induced mutations will remain an important tool in this box, especially for a) those with no or limited access to the new, more expensive technologies; b) locally preferred varieties; and c) vegetatively propagated crops. Knowledge-based induction of mutations in specific genes, single residue replacements at the desired position (site directed mutagenesis), and more effective selection methods will enhance the overall utility of the technique.

Mutants will remain the basic resource for identifying genes and understanding their function at the molecular level. With the advancement of plant molecular biology, their importance will only increase. Mutation induction is one of the most efficient and cost effective tools for functional genomics and proteomics.

Agriculture will remain the engine of economic growth for many nations. Increased crop productivity supports overall agricultural growth. Mutations are the source for providing efficient metabolic pathways to produce new, value-added, crops and the products derived from them.

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"When eating fruit, think of the person who planted the tree." A Vietnamese proverb.

H. J. Muller (1927): Demonstrated that mutations can be induced by X-ray exposures.

L. J. Stadler (1930): Extensively induced mutations in maize.

H. Nilsson-Ehle and A. Gustafsson pioneered mutation research for crop improvement in Sweden in 1928.

TABLE I. IMPACT OF INDUCED MUTATIONS IN RICE IMPROVEMENT

Country	Cultivars	Coverage (hectares)
China	18	30,000 - 70,000 each
	8	70,000 - 200,000 each
	3	200,000 - 700,000 each
	2	> 700,000 each
	Yuanfengzao	6,000,000 (1975 - 83)
	Zhefu 802	10,600,000 (1962 - 94)
	Other Zhefu	14,000,000 total
Japan	Aki-hikari	2,000,000 -3,000,000
	Reimei	2,000,000 - 3,000,000
India	Jagannath	Large area in 4 eastern States
California ¹	Calrose 76	220,000
	M-7	450,000
	M-101	150,000
	S-201	675,000
	M-301	150,000
Myanmar	Shwartum	4,800,000
Thailand	RD6	2,400,000
Australia	9 hybrids of Carlose 76	Extensive
Egypt	2 hybrids of Carlose 76	
	Giza 176	Leading variety
	Sakha 101	

¹ Cultivars listed occupy 54% of area devoted to rice growing in the state

TABLE II. OTHER SUCCESS STORIES

Crop	Impact of Induced Mutations
Cereals	<p>Semi-dwarf, malting barley cultivars (150) in all continents carry <i>denso</i> gene from cultivar Diamant, an induced mutant of cultivar Valticky. Estimated area by 1987 was 2.86 million ha.</p> <p>Eleven barley cultivars derived from the original three cultivars 44/3, Pallas and Mari in Sweden. Extensive studies on induced mutants for powdery mildew resistance at the <i>mlo</i> locus has led to the use of the natural mutant from Ethiopia in European barley breeding.</p> <p>Thirty eight wheat cultivars released in USA have original mutant cultivars Payne, Lewis and Stadler in their pedigree.</p> <p>Rice mutant cultivars released in Burkina Faso, Ivory Cost, and Senegal.</p> <p>Eight sorghum mutant cultivars and three of African rice released in Mali.</p>
Oil seeds	<p>New cultivars with altered fatty acid composition released in rapeseed, sunflower and linseed/flax. Linseed previously only a source of non-edible oil, converted to edible oil crop - Linola.</p> <p>Modern sunflower hybrids and cultivars grown in Europe and USA with high oleic acid derive the character from mutant cultivar Pervenets.</p> <p>Castor bean (<i>Ricinus communis</i>) mutant cultivar Aruna and its derivatives replaced older cultivars under rainfed cultivation due to their early maturity in India.</p> <p>Currently, 9% of the total groundnut breeder's seed in India is for mutant cultivar TAG-24, and another 2% for older TG cultivars.</p> <p>With inter-mutant crosses and selection in India, partitioning of dry matter to pods and seeds in groundnut enhanced to over 52%, same pod yield can be harvested now in about 100 days that was obtained in 130-140 days.</p> <p>Five sesame mutant cultivars released in Egypt.</p>
Legumes	<p>Mutants showing altered host-symbiont relationship leading to hyper- and nitrate-tolerant nodulation isolated in several grain and fodder legumes.</p> <p>Soybean cultivar Nitrobean with hyper- and nitrate-tolerant nodulation released in Australia.</p> <p>Many cultivars of common bean (<i>Phaseolus vulgaris</i>) in USA derive bushy habit from induced mutant cultivar Sanilac.</p> <p>Moth bean (<i>Phaseolus aconitifolius</i>) mutant cultivar RMO-40 which escapes drought due to early maturity is grown over a large area in the state of Rajasthan, India.</p> <p>Day length neutral mutant of stem nodulating <i>Sesbania rostrata</i> after 55 days growth can provide equivalent of 60 kg N/ha to the following rice crop.</p>
Fruits	<p>Two grapefruit mutant cultivars Star Ruby and Rio Red with red flesh, and seedless are grown on over 7,300 ha (75% of area) in Texas, and sold under trade name Rio Star.</p> <p>Seedless <i>Citrus</i> cultivars developed in China and South Africa.</p> <p>Banana cultivar Novaria released in Malaysia, two clones developed in Sudan, and Sri Lanka.</p>
Mint	<p>Peppermint cultivar resistant to <i>Verticillium</i> wilt, Todd's Mitcham, forms bulk of the world's production of mint oil. Murray Mitcham and Todd's Mitcham are two of the three resistant types in USA.</p>

TABLE III. EXAMPLES OF ECONOMIC GAINS FROM MUTANT CULTIVARS

Cultivar	Economic Gain (millions of US\$, except as noted))
Semi-dwarf rice in California, USA	20.47
Durum wheat in Italy	180
Disease resistant Japanese pear “Gold Nijisseki”	30
18 rice mutant cultivars in Japan	937
NIAB 178 cotton in Pakistan	Rs. 9,300 million over 3 years
Jauhar 78 wheat in Pakistan	19 (1983 - 1990)
Sind 81 wheat in Pakistan	14 (1983 - 1990)
Sarsabz wheat in Pakistan	78 (1983 - 1990)
Various NIAB mung bean cultivars in Pakistan	20 per year
TAU-1 blackgram (<i>Vigna mungo</i>) in Maharashtra state, India	64.7 per year

TABLE IV. EXAMPLE OF RETURN ON INVESTMENT IN MUTATION RESEARCH

Crop	Blackgram
Location	Maharashtra State, India
Average yield in 1989	419 kg per hectare
Average yield in 1999	631 “ “ “
Yield increase due to mutant cultivar TAU-1	212 “ “ “
Additional annual production from TAU-1	1,294.000 metric tonnes
Price per ton	Rs. 20,000
Additional annual income	Rs. 2,588,000,000
Total expenditure on blackgram mutation research at BARC for 10 years	Rs. 10,000,000

UTILIZATION OF SALINE WATER AND LAND: RECLAIMING LOST RESOURCES

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There is an abundance of saline water on the globe. Large tracts of land are arid and/or salt-affected, and a large number of plant species are known to be salt-tolerant. It would seem obvious that salt tolerant plants (halophytes) have a role in utilizing the two wasted resources, saline water and wastelands. We will briefly describe how these resources can be fruitfully utilized and how the IAEA has helped several countries to demonstrate the possibility of cultivating salt tolerant plant species on arid saline wastelands for economic and environmental benefit. After some brief introductory remarks we will discuss the results of the project.

Introductory Remarks

Of all the water on the earth, 97% is in the oceans and 2% is held up in ice caps, leaving just 1% for possible exploitation. Of this 1%, more than half is groundwater of varying salinity levels, while the rest is in rivers, lakes, and in the biological systems. The uneven distribution of this 1% over the globe has left large arid or semi-arid areas, located mostly in the developing countries, where the population, and thus the need for fresh water, is rapidly rising.

Soil salinity is a world-wide phenomenon. Its many interrelated causes include geographical, geological and anthropological factors. FAO estimates that human practices account for 77 million hectares of salt affected lands. Here, saline soils are due to bad management of irrigation or removal of plant cover leading to excessive evaporation. In addition, naturally arid wastelands are spread over a far greater area.

Moderate to high salinity groundwater is present at varying depths in many of the arid and semi-arid salt-affected areas of the world. This water is a resource that can be used to grow salt tolerant plants. Plants are the best means of harnessing the maximum amount of solar energy per unit land area. Plants use solar energy to combine carbon dioxide from the air and water from the soil to produce carbohydrates and other products. They convert solar energy to stored chemical energy that can be used by man in a variety of ways. Agriculture is, in fact, the science of harnessing solar energy through plants. This energy is not only stored in the plant but is also the driving force for the nutrient cycle in the soil and for providing energy to soil microbes such as those fixing atmospheric nitrogen.

Plants also have a wide genetic variability; they grow on the mountains, in the plains, in deserts, and even in the sea. Man has so far exploited very little of this variability. For example, out of the 25000 species of higher plants (Angiosperms) only 2% are commercially used. A large number of plant species are known that can survive, and even thrive, under high salinity conditions. Using saline water these could be grown to: provide green cover, conserve moisture, sequester atmospheric carbon dioxide, help stop soil erosion, and desertification and provide biomass for food, forage, fibre, fuel, fertilizer (organic manure), and feedstock for industry.

The IAEA Project

The International Atomic Energy Agency (IAEA) is supporting an Interregional Model Project on Sustainable Utilization of Saline Groundwater and Wastelands for Plant Production in 9 countries of North Africa, West Asia and South Asia. Morocco, Tunisia, Egypt, Syria, Iran and Pakistan started the project activities in 1997, while Jordan, UAE and Algeria joined later. The project is meant to 1) demonstrate the possibility of growing economically useful plant species on wastelands using saline water for irrigation (biosaline agriculture); and 2) assess the feasibility of extending the activity to a larger area. The activities were started on 10 hectare Demonstration Sites located in deserted areas where some groundwater, though saline, was present.

The project involves the following major activities.

- Introduction of known salt tolerant plant species (halophytes) on 10 hectare Demonstration Sites irrigated with pumped saline groundwater and selection of those species that have a comparative advantage in terms of survival, economics and acceptability to the end user.

- Irrigation with saline groundwater and its proper management, using nuclear and other techniques, to ensure that salts do not build up on the soil surface. The agriculture activity will not be sustainable if salt is allowed to build up.
- Monitoring of groundwater dynamics by chemical and isotopic analyses to determine the quality and, eventually the rate of recharge, to assess water availability and sustainability.

Transfer of technology to the end user/beneficiary

A multi-disciplinary project with a user-orientation required a team effort. The IAEA helped train people for the varied activities of the project, mostly during its first year. Interregional meetings, In-Country Workshops, Training Courses, Scientific Visits of senior staff, and Expert Services were all arranged within the participating countries to provide opportunities to share experiences, to exchange materials, and to facilitate TCDC. Initial difficulties to be overcome included working in a hostile arid environment with little or no infrastructure; using an unconventional approach; facing a dearth of the desired level of expertise and motivation of the project personnel; and establishing the necessary coordination. However, these challenges were met and the activities are now very productive.

The six countries that initiated work on the project in 1997 have clearly demonstrated that it is possible to cultivate economically useful salt tolerant plants using the wasted resources, namely, high salinity water and arid/saline wastelands. The plant species, mostly perennial and nitrogen fixing, were introduced on the sites and irrigated with moderate to high salinity water without any other input (minimum tillage, no fertilizer, no pesticide). Nuclear techniques (neutron moisture gauges) were used to optimize irrigation and to develop water management regimes that could be passed on to the end user. There is no report of salt build-up on the soil surface, indicating that irrigation was well managed. Using nuclear techniques, the monitoring of the groundwater has provided useful information that is being interpreted to assess the extent of sustainability of the water resource.

Although there are hundreds of salt and drought tolerant species known, just over 30 were recommended for the Demonstration Sites. The sites are all located within the latitudes 25 to 40 degrees North, yet the weather conditions, the quality of soil and water, and even economic conditions, vary from site to site and country to country. The recommended species were mainly chosen for forage and food (e.g., species of Barley, Brassica, Atriplex, Kochia, Leptochloa, Sporobolus, Haloxylon, Acacia, Prosopis, Olive, Date Palm, Wild Olive, and Cactus); for stabilization of the soil, as wind breaks and for improvement of environment (e.g., Tamarix, Casuarina, Eucalyptus, Acacia, Prosopis); and for improving the structure and fertility of the soil (most of the above). Another consideration was that most of these species, or their near relatives, are native to these countries so that adaptation will be no problem.

After initial introduction and successful establishment of a larger number of plants, some of those economically relevant to the respective countries have been selected and are being passed on to the end users.

Conclusions

Reliance on the vast capabilities of plant species, and their optimum exploitation under saline conditions, is a key element of the IAEA Model Project. The plants are grown not only to produce biomass but also as a source of energy, and to improve the soil and environment. It has been clearly demonstrated that part of this potential can easily and inexpensively be exploited to fruitfully utilize saline water and wastelands for economically viable, tough unconventional, agricultural activity. The results will be presented through photographs of the initial and present situations on the Sites in different countries.

The salt tolerant plant species tried on the sites include grasses, bushes and trees, some tall growing, others bushy and spreading. Selection for large areas in the respective countries depends upon their socio-economic conditions and demands.

The sustainability of the activity depends mainly on two key factors, (a) the management of irrigation so that salts from the water are not allowed to accumulate on the top soil that plants mainly use for their growth; and (b) continued availability of the (saline) water.

Nuclear techniques have a key role in establishing sustainability of the activity. Soil moisture measurements using nuclear techniques provided information on irrigation regimes required for optimum plant growth and for leaching salts from the top soil. There have yet been no reports of accumulation of salt on the soil at demonstration sites or farmers' fields.

Using Isotope Hydrology techniques, complemented with chemical analyses of the groundwaters from several locations in a radius of 2 to 10 km around the sites, information has been collected on the quality, and possible sources and rates of recharge of the aquifers,. This information will determine the sustainable rate of water utilization in a given area.

The project was difficult because of the hostile environment and because of its new approach. The difficulties were overcome through different approaches. Biosaline agriculture is not a usual activity. People, including the project personnel, were skeptical about its success. After the initial difficulties were surmounted and a number of plant species started growing well in densely laid out plots, the workers did get motivated. SEEING IS BELIEVING. Organization of Farmers' Days and Workshops have convinced many farmers also.

Saline agriculture, as demonstrated through the project activities, is a low cost technology suitable for the arid areas that are inhabited by the poorest sections of the population in many countries.

Through the project some awareness has been created among the scientific community, government, and the end users that biosaline agriculture can be a feasible option for specific arid areas.

ETHIOPIA'S NATIONAL STRATEGY FOR IMPROVING WATER RESOURCES MANAGEMENT

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Ethiopia's current approach to assessing and managing water resources, including geothermal, assigns very high priority to the use of isotope hydrology. Incorporation of this technology into government planning began with a few activities, in local groundwater assessment and in geothermal studies, kicked off by a 1993 National Isotope Hydrology Training Workshop that the IAEA helped arrange. The first results of isotope studies were useful in characterizing the Aluto Geothermal Field, where a 7.2 MW(e) power plant was later built with support from the UNDP and the EEC. And the Government is now hoping to introduce isotope techniques to improve utilization of the field.

Isotope hydrology has successfully aided attempts to better understand ground water occurrence, flow and quality problems in arid regions of Ethiopia. These efforts are continuing through studies in the Dire Dawa, Mekelle and Afar regions.

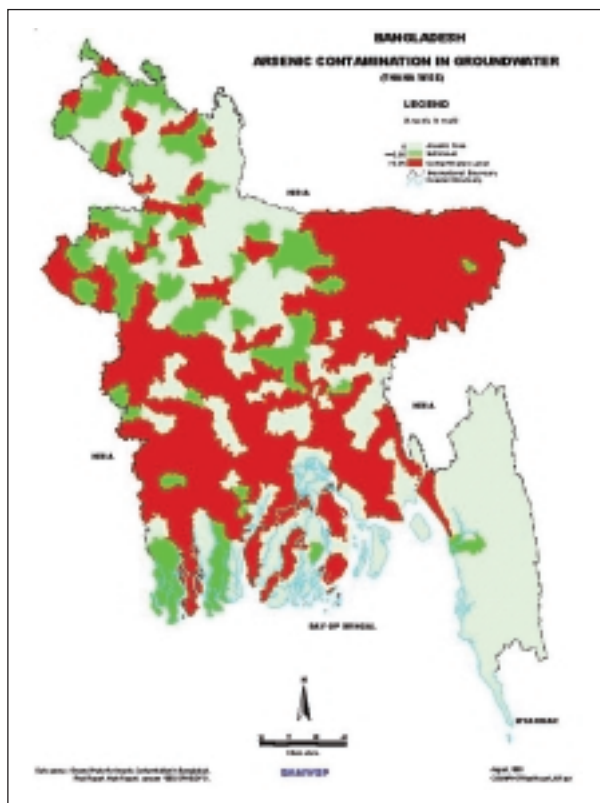
Rising water levels in Lake Beseka are threatening to submerge vital rail and highway links. Isotope hydrology made a unique contribution to understanding the surface and subsurface factors responsible, leading to an engineering plan for mitigating the problem. The Government has allocated substantial funding and construction work has begun. A similar success story is emerging at Awassa Lake, where isotope hydrology is proving a very useful complement to conventional techniques.

Another promising application of isotope hydrology is taking place as part of the Akaki Groundwater Study near Addis Ababa. Preliminary isotopic results indicate that earlier conclusions based on conventional techniques may have to be revised. If so, there will be significant implications for the exploitation and management strategy of the resource.

Based on these encouraging results, the Government is proceeding with the preparation of a project document for the Ethiopian Groundwater Resource Assessment Programme. With the assistance of the IAEA, the U. S. Geological Survey played a leading role in conducting a National Workshop that designed the programme's basic features.

UNDERSTANDING ARSENIC CONTAMINATION OF GROUNDWATER IN BANGLADESH

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The problem of water contamination by naturally occurring arsenic confronts governments, public and private utilities, and the development community with a new challenge for implementing operational mitigation activities under difficult conditions of imperfect knowledge—especially for arsenic mitigation for the benefit of the rural poor.

With more than a conservative estimate of 20 million of its 130 million people assumed to be drinking contaminated water and another 70 million potentially at risk, Bangladesh is facing what has been described as perhaps the largest mass poisoning in history. High concentrations of naturally occurring arsenic have already been found in water from tens of thousands of tube wells, the main source of potable water, in 59 out of Bangladesh's 64 districts. Arsenic contamination is highly irregular, so tube wells in neighboring locations or even different depths can be safe. Arsenic is extremely hazardous if ingested in drinking water or used in cooking in excess of the maximum permissible limit of 0.01 mg/liter over an extended period of time.

Even in the early 1970s, most of Bangladesh's rural population got its drinking water

from surface ponds and nearly a quarter of a million children died each year from water-borne diseases. Groundwater now constitutes the major source of drinking water in Bangladesh with 95% of the drinking water coming from underground sources. The provision of tube well water for 97 percent of the rural population has been credited with bringing down the high incidence of diarrheal diseases and contributing to a halving of the infant mortality rate. Paradoxically, the same wells that saved so many lives now pose a threat due to the unforeseen hazard of arsenic.

Bangladesh is a developing country with a GNP per capita of US\$280 and a population of over 130 million. Its population density is very high, and most people live in small to medium sized villages (500-3,000 cap). Most of the country is a flat deltaic area with soft soils and high water table. This allowed the successful introduction of shallow and medium-deep hand pumps since the seventies. Although estimates vary, recent counting suggests that possibly near 10 million hand pumps are being used, of which 10% have been installed by the Government with UNICEF assistance, and another 10% by NGOs (DCH/Uposhon 2000). The majority of the pumps seem to have been installed on private initiative. The size of the affected area, the very large numbers of people “at risk”, and the often very high arsenic concentrations (well above 0.5mg/L) make it decidedly a priority concern at national scale.

The provenance of arsenic rich minerals in sediments of the Bengal basin as a component of geological formations is believed to be from the Himalayan mountain range. Arsenic has been found in different uncropped geological hard rock formations underneath Bangladesh. Logically, arsenic is likely to be present as compounds within sediments comprising the aquifer systems and may be associated with iron oxides, organic matter, sulfides etc. High arsenic contamination of groundwater in Bangladesh is a serious issue requiring appropriate understanding of the phenomenon relating to the occurrence and release of arsenic in groundwater.

The water supply challenge is as much one of quantity as of quality. In many regions of the world, it means bringing water closer to the house. Further, if the water supply is of good quality, it improves public health. Three developments of the past decades have spurred new approaches to water supply and public health. First, the capacity to analyze smaller amounts of constituents in water has advanced substantially. Second, the health status and life expectancy have risen substantially across most countries. Finally, health and epidemiological research have advanced as well, and we are now much better informed of longer-term health effects of prolonged ingestion of contaminants.

Arsenic is currently the most significant example of a natural water contaminant present in relatively low concentrations. Its acute toxicity has been known for thousands of years, but the enhanced capability to detect very low concentrations in water has allowed to link arsenic to the incidence of cancer. This is especially worrisome because, in contrast to many other contamination types, we do not dispose of simple technologies or alternatives to mitigate the problem, especially in the case of isolated rural households.

The consensus among experts is that it is a priority to provide arsenic-free drinking water, partly because it is a *preventive* measure, and partly because in many arsenicosis patients clean water flushes out excess arsenic from the body and reverses to a major extent disease symptoms (see WHO 1997). Therefore, the strategy concentrates in first instance on water service delivery rather than strictly on health care.

There are, at present, few (if any) low-cost technology and affordable solutions for the treatment of arsenic in non-piped water systems. Proposed interventions in rural areas must include alternative water sources such as rainwater harvesting, more efficient use of non-contaminated wells in the area, treated surface water, selective well drilling to deeper aquifers, and simple arsenic removal techniques as they are found effective.

Arsenic contamination apparently can occur in a wide variety of hydrogeological and socioeconomic conditions. Therefore, any mitigation strategy will have to be tailored to suit the local geological, institutional and financial situation. However, the experience with water supply across the world demonstrates that the offered technical options will be sustainable only when the local community, or the customers, are truly committed to it and are willing to contribute financially to (at least) the operation and maintenance of the system.

The arsenic “crisis” has taught that the use of groundwater for water supply – and for that matter also agricultural irrigation – needs much more thorough scrutiny with respect to its chemical composition. In general, if arsenic now has proved to be more widely present in groundwater than originally thought, and if it has such dramatic health effects that occur after long-term ingestion, then other low-concentration elements in groundwater may equally be a cause or a factor in other disease patterns. This requires simpler techniques to determine water quality of different aquifers and the long-term safety of these aquifers. Isotope hydrology has proved to be a good tool in Bangladesh to identify source of water in different aquifers.

Water quality dimensions are often absent in on-going efforts to clarify, codify, and implement the policy, legal and institutional dimensions to promote groundwater use for economic and social development, particularly in the developing world. Moreover, past water and sanitation projects financed by the World Bank and other donor agencies have rarely included a systematic consideration of groundwater quality issues. Our belief is that some of these issues require urgent attention - such as the need to immediately include and implement the systematic analysis of groundwater quality in the environmental analysis of development efforts with a groundwater component or impact.

TABLE 1: COMPARISON OF WORLDWIDE LEVEL OF THREAT TO HEALTH POSED BY DIFFERENT WATER SUPPLY DEFICIENCIES

Problem faced	People affected (Magnitude)	Health effect	Remedies available	
			Type	Technical complexity
Limited access to drinking water	<i>Only developing countries:</i> 1.5 billion ¹	Various	Increase coverage by replicating water supply programs	Moderate
Gastro-intestinal diseases due to water-carried pathogens	<i>Only developing countries:</i>	Diarrhea, cholera, Often fatal	Improve hygiene behavior, sanitation, disinfect water	Low
Lead in water supply (Distribution pipes)	1 million	Neural / cerebral disorders	Replace lead pipes and fixtures	Low
Fluoride in water supply (Groundwater)	<i>Mostly in developing countries:</i> 5 million	Tooth decay, bone deformation	Remove fluoride, <u>or</u> provide water from alternative source	Moderate
Arsenic in water supply (Groundwater)	<i>Mostly in developing countries:</i> 50 million	Skin diseases, intestinal cancers; often fatal	Remove arsenic, <u>or</u> provide water from alternative source	Moderate to high

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NEONATAL SCREENING FOR TREATABLE CONGENITAL DISORDERS

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Background

Congenital hypothyroidism is a treatable disease if detected at the early stage of life. It is one of the most frequent cause of mental retardation in children. In 85 % of cases, congenital hypothyroidism is a consequence of thyroid dysgenesis, in which the gland is either absent, located ectopically and/or severely reduced in size. Early detection and treatment with thyroid hormone supplement can significantly reduce mental damage.

In 1996, Thailand initiated a neonatal screening programme for congenital hypothyroidism (CHT) and phenylketonuria (PKU), with the objective of bringing a better quality of life to people throughout the country, but especially in the remote areas. The programme involves implementing routine screening nationwide. The plan of action was designed with the goal of having public health service units throughout the country provide neonatal screening by year 2002 for the 1.2 million babies born per annum in Thailand. The government supported the programme by allocating a five-year budget of approximately US\$15 million. The programme received additional assistance through technical support and human resource development from the International Atomic Energy Agency (IAEA) and the US Centers for Disease Control. This assistance promoted self-sustainability and strengthened the programme's technical base.

The programme is on track. It is expected that by year 2002 all new born babies in Thailand will be screened for CHT and PKU.

Methodology

The implementation of the screening programme has been performed through public health sectors all over the country. These involve: education of the health personnel as well as communities, implementation of routine specimens collection, delivery system to central laboratories, establishment of central laboratory screening services and routine follow up of the case management. Local in house reagents using ELISA and IRMA techniques have been developed and utilized as screening and confirmation tests for CHT. In addition, Guthrie's test has been used for PKU screening and automated Fluorometry has been selected for PKU confirmation.

Results

Since the beginning of NSP in 1996, the number of provinces participating in the programme and the number of babies screened have increased steadily. So far 1,425,025 babies in Thailand were screened and it was found that 3,450 (0.24%) were above the first screening cut off for CHT and 321 (0.02%) for PKU. (TSH > 25mU/L and PKU > 4 mg/dl). With 65.5% follow-up, the incidences were confirmed as 1:3,314 for CHT and 1:285,005 for PKU. In addition, all 724 community hospitals provided the screening services as one of the basic requirements for newborns according to the public health policy.

Conclusion

The NSP has been implemented as routine practice for all public health sectors all over the country for CHT and PKU. It is expected that by the year 2002, all Thai newborns will be provided with the screening services resulting in a better quality of life for the next generation.

STABLE ISOTOPES FOR IMPROVING HUMAN NUTRITION

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The developing regions of the world are undergoing a rapid demographic and epidemiological transition. The number of child deaths and disease, and their causes, are important markers for this change and serve as indices of human development. More important to society at large is the change in the pattern of child growth of the survivors. Although they survive, a large proportion of children in developing countries fail to grow physically and develop mentally, thereby affecting not only health but also educational performance and economic productivity. National development is retarded at its root.

In societies undergoing demographic transition, decreases in fertility rates usually lag behind changes in mortality by several decades. Thus, rapid population growth is typical of this transition. Dietary determinants of nutrition and health of populations undergoing transition also change. Typically, predominantly cereal-based food consumption patterns change to ones incorporating a greater proportion of animal food products, higher total fat and saturated fats, and a progressive inclusion of industrially processed food in the diet.

The rural poor come to the cities and become the urban poor. They tend to live in precarious housing in unsanitary environments. Working merely for subsistence, they place great demands on governments to provide health and education services. The political dimension of these unsatisfied demands, in terms of unmet basic human needs, characterises life in developing societies. This situation not only fuels political struggles but is also the cause of great frustration to concerned scientists and health professionals. The impact of nutrition on infant survival and child growth is at the heart of what matters in the developing regions of the world.

Most countries undergoing the nutrition transition have supplementary feeding programs and other major nutrition interventions targeted mainly at the urban and rural poor. For example, a recent FAO review of nutrition programs in 19 Latin American countries found that over 20 percent of the population — approximately 83 million people out of an estimated 414 million in the study countries — receives some level of benefits in nutrition-related programs. The allocation of limited national and international assistance resources for these activities in the region is on the order of several billion dollars annually. Undoubtedly these programs are influencing child growth. Significant reductions in underweight and wasting have occurred; but stunting has been more resistant to change. In this setting providing food supplements may be beneficial for some while it may be detrimental for others. The definition of who should benefit from the programs and what is the right combination of nutrients/foods, education, and lifestyle interventions that is required to optimise nutrition and health at each stage of the life cycle is a truly complex problem. This demands the use of the best scientific tools to define who should benefit, what should be done and measured as an outcome, how programs should be evaluated, when programs should be expanded, and when they should be stopped.

Isotopic and nuclear techniques are tools, not solutions. This presentation will serve to demonstrate how isotopes can contribute to refining nutrition interventions and their impact on public health.

Isotopic methods can shorten the time needed to evaluate impact, because they provide sensitive measurements of biological effects. They are faster than traditional methods such as anthropometry for detecting changes in growth and body composition. Micronutrient malnutrition, and especially the bioavailability of vitamins and minerals from traditional foods, are not well evaluated using routine biochemical methods. Radioisotopes have been used successfully in the past. But recent developments in stable isotope techniques offer unique advantages for the design and evaluation of programmes that address, e.g., vitamin A, iron and zinc nutrition. Copper deficit and excess also have important implications for human health. Here, isotopic methods for measuring absorption, storage and excretion permit a more precise definition of the range of exposures that are tolerated without adverse effects.

The mandate of IAEA to support national governments, UN agencies and others in using nuclear procedures to monitor the impact of interventions, demographic change and development is being served by regional

technical cooperation projects in Latin America, Africa and Asia. Building local capacity has been incorporated in the process, establishing networks to support local programs, training activities, and laboratories. These efforts will serve applied researchers and planners who need the practical applications of novel methodologies to improve nutrition and the well being of under-served populations world-wide.

RADIOTHERAPY FOR CANCER TREATMENT: A GROWING PRIORITY FOR DEVELOPING COUNTRIES

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Located in Central America, Costa Rica at present has a population of 3.8 million inhabitants, equally distributed among men and women.

Costa Rica has a centennial democracy and decided to abolish the army 50 years ago. What is not spent on the army is invested in health, education and national development. However, despite the country's high levels of human development, its economic resources are insufficient to meet all social needs.

Costa Rican efforts to fight cancer started in 1940, with the creation of an Institute to Fight Against Cancer, funded through a special tax. However, national reality forced the government to eliminate this tax. Thereafter, funds raised in other ways were mostly used to strengthen the existing primary care programs.

During the 50s Costa Rica started an intensive program of primary health care, because infectious diseases such as diarrhea, parasitosis, tuberculosis and malaria were the main cause of mortality among the population. At that time, the infant mortality rate was 90.2 per 100 live births. Investment in primary care demanded huge economic resources, especially in infrastructure. In 1964, the National Children's Hospital was dedicated. This medical center modified the hospital concept of Costa Rica's pioneers in social security. It joined the existing centers: the San Juan de Dios Hospital (1845) and the Dr. Rafael Angel Calderon Guardia Hospital (1943). In, 1969 the newest national hospital, the Mexico Hospital, was built.

The epidemiological profile completely changed: the infant mortality rate dropped, life expectancy at birth increased, and many infectious and parasitic diseases were eliminated. However, there was at the same time an increase in degenerative and cardiovascular diseases, and in cancer.

It was not until the 70s, 30 years after the first effort to fight cancer began, that the first cobalt teletherapy unit was purchased to assist cancer patients. This unit was a THERATRON 80, installed at the Mexico Hospital shortly after its opening. In 1975, a campaign to purchase a second cobalt unit was organized. The so-called "March of One Colon-coin" consisted of voluntarily contributing \$0.05 per person. At the end, the goal was reached and the unit was installed at the San Juan de Dios Hospital, in the capital city. With these two cobalt units, plus a third one donated in 1992, Costa Rica was poised to address the radiotherapy needs of its 2 million inhabitants.

However, in 1995 a team of physicians of the Calderon Guardia Hospital noted with great concern that despite earlier efforts, mortality associated with the five most frequent cancer types had not decreased. A study of cancer incidence in the country was started. However, just as the study was beginning, there was a deplorable accident with one of the cobalt units. In 1996, 115 patients were seriously over-irradiated. This sad event made cancer a very important political and medical issue in Costa Rica.

As a consequence of this accident, the International Atomic Energy Agency (IAEA) made a comprehensive assessment that revealed deficiencies in quality assurance practices. The assessment also established that a) the radiotherapy equipment had exceeded its useful life, estimated at 15 years; b) the country lacked adequate treatment standards; c) there was a shortage of trained personnel; and d) some brachytherapy equipment had expired 10 years previously.

Because of this situation, the Costa Rican Institute Against Cancer (known by the acronym ICCC in Spanish) was created in 1998. Its mission is to support and promote cancer prevention and control. An important fact is that the legislation creating the ICCC states as a priority the construction of a specialized hospital.

Planning for the new facility was based on the estimated 7,000 new cancer cases every year in Costa Rica, of which 40% (2,800 patients) involve radio-sensitive tumors. Of these, about 30% (840 patients) must receive linear accelerator therapy. Given that each linear accelerator may treat 400 patients a year, and taking into consideration that the construction of a specialized hospital must be through public contract (a very complicated and slow process in Costa Rica), the Costa Rican Social Security Fund (Spanish acronym CCSS) decided to

purchase three new cobalt units (THERATON 780-E Model 2000), new brachytherapy equipment, two linear accelerators, and X-ray equipment for superficial therapy.

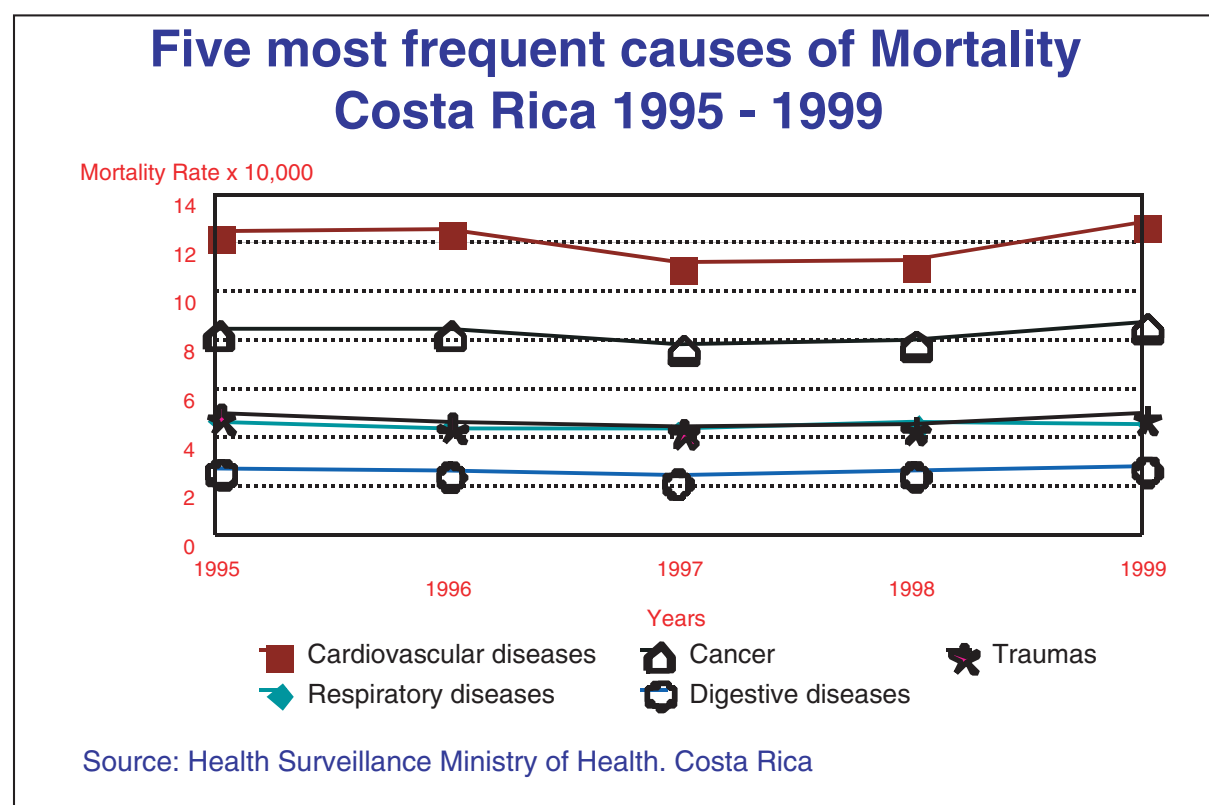
Likewise, an early detection program was implemented for cancer of the uterine cervix, which now covers 96% of its target population. A pilot plan for breast cancer detection was started. There are also plans to implement a nationwide gastric cancer detection program, currently sponsored by the Japanese Government.

Costa Rica has created a National Plan for Managing Cancer, with a strategy focused on three basic aims: creation of a program to promote health that includes early assistance with certain types of cancer; treatment of cancer using state-of-the-art technology (teletherapy and brachytherapy) and provision of the palliative care needed by a considerable number of patients. Regarding this last issue, the ICCC gives economic support to 10 foundations and non-profit associations that provide this service, and it promotes the creation of more.

AN ONCOLOGICAL SYSTEM FOR COSTA RICA

To modify the cancer profile in Costa Rica, some complementary actions are needed.

There would be no benefit for the country if it had the most sophisticated and complex equipment and an exemplary hospital infrastructure but lacked duly trained human resources. Thus, this last issue, training, is included in the Letter of Understanding signed with the IAEA, so there will never again be accidents in Costa Rica such as the one in 1996.



BIOTECHNOLOGY FOR DEVELOPMENT: HUMAN AND ANIMAL HEALTH PERSPECTIVES

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Development will bring food security only if it is people-centered, if it is environmentally sound, if it is participatory, and if it builds local and national capacity for self-reliance. These are the basic characteristics of sustainable human development. James Gustave Speth (UNDP, 1994)

Introduction

In much of the world, resources for human life are meager at best. While the developed parts of the world enjoy a standard of living higher than at any time in history, the benefits of technology and industrialization have not been available to developing countries. The extreme lack of resources leads to very slow progress despite intense interest and hard work; thus the technological gap between developing and developed nations continues to widen, as discoveries and advances accelerate in the more favored countries while technological accomplishments of developing nations are soon outmoded. It is apparent that developing nations will not be able to overcome this disadvantage if the situation is not addressed soon.

Developing nations should not be condemned permanently to such status. It is essential for world political and economic stability to develop orderly plans to help struggling nations advance to technological production levels rather than exist as marginal consumers. It is essential that all projects in such countries have distinct, stated goals for conversion of the developing nation to a developed nation, and that such goals be the overriding consideration in the direction of the project.

Cognizant of the significance of the recommendations and with a real desire for prompt implementation, we have established an “International Laboratory of Molecular Biology for Tropical Disease Agents (ILMB)” whose main agenda is the transfer of biotechnology to developing countries. In this spirit, we have entered into partnership with a number of international organizations including the United States Agency for International Development (USAID), a number of United Nations Agencies such as the International Atomic Energy Agency (IAEA), the Organization for African Unity (OAU), and a number of countries from the developing nations in Africa and Asia. We are working with these partners toward:

- establishment of laboratories of molecular biology in developing countries;
- training of scientists in the new technologies through graduate programs, postdoctoral fellowships, and workshops given in developing nations, and, specifically,
- the transfer of technologies in the development of recombinant vaccines and rapid diagnostic kits for improving both human and animal health.

To illustrate these points, a few examples of the contributions of the ILMB will be provided under the heading of human and animal health and the transfer of technologies to developing countries.

Human Health

According to the World Health Organization (WHO) report of December 2,000, there were more than 5 million newly infected and over a total of 36 million people living with AIDS. Death due to AIDS in 2000 was more than 3 million. Developing nations in Africa and Asia carry the greatest burden of AIDS. Simple, inexpensive, and effective vaccines and post-infection therapies for human immunodeficiency virus (HIV) infections are desperately needed to control or diminish the spread of AIDS.

In addition to the discovery of the causative viral agent, three important contributions have been made in the development of recombinant vaccines for AIDS using animal models:

- classical or recombinant vaccines do not provide a sterilizing immunity but only reduce viral load;
- an attenuated live vaccine with a deletion in the *nef* gene provides sterilizing immunity; however, it causes persistent infection and is lethal for some neonates and juveniles, and
- the replacement of the *nef* gene with a lymphokine gene enhances both safety and efficacy of the vaccine.

The ILMB provided contributions 1 and 3 (Ahmad et al, 1994; Giavedoni et al., 1993; 1996; 1997). Currently, we have employed an attenuated vaccine expressing interferon- γ as both a prophylactic and therapeutic vaccine.

Animal Health

The ILMB has made strong contributions toward the development of recombinant vaccines and rapid diagnostic kits for important livestock diseases. We have developed a safe and highly efficacious recombinant vaccine for one of the most deadly disease of livestock, rinderpest. This vaccine is heat-stable, inexpensive, easily-administered, and allows serological differentiation between vaccinated and naturally infected animals. Consequently, prospects for global eradication of rinderpest through mass vaccination of cattle are outstanding (Yilma, Giavedoni, Verardi, Ismail). Dr. Gordon Ada, the internationally renowned immunologist, described the rinderpest vaccine as one of the two outstanding live recombinant vaccines in the world (*Nature* 349: 369, 1991). The other is VRG, currently in use for eradicating rabies in Europe and the US. Our recombinant vaccine for rinderpest has been showcased at prestigious international meetings. For example, the vaccine was selected for presentation to illustrate the benefits of animal biotechnology at the Annual Meeting of the American Association for the Advancement of Science in Atlanta, Georgia.

Technology Transfer

Our accomplishments in the transfer of technology to developing countries have been acknowledged and supported in a number of scientific journals, including *Nature* (Stevens, Vol. 355, p. 194: 16 January 1992) and *Science* (237:1289-1291, 1987 — War on Cattle Disease Divides the Troops.). Currently, the ILMB, in collaboration with IAEA and USAID, has just completed the transfer of an inexpensive, simple rapid diagnostic kit for rinderpest to Africa.

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The background is a deep blue gradient. In the upper half, there is a faint, stylized image of a globe with a grid of latitude and longitude lines. In the lower half, there is a silhouette of a city skyline with several tall buildings. A large, thin, white arc curves across the middle of the image, passing behind the city skyline.

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