Applying nuclear techniques to agriculture in Brazil

by P. Willstätter-Greig*

Technical co-operation is a term used widely in the UN system. It can mean, and has meant, various things – from the simple transfer of skills or equipment (what was formerly called 'technical assistance') to genuine partnerships and mutual assistance among all parties involved. The goal in Latin America is the latter, much more demanding type of co-operative partnership.

In many senses, Latin America is a region of contrasts: political, geographic, economic, climatic, social and technological. Within Latin America there are a few countries with well-developed technological infrastructures and comparatively high levels of economic, social and scientific development. For example, Argentina, Brazil and Mexico are all on the way to becoming full-fledged industrial states. Other countries in the region show a wide spectrum of development, with a few still in the 'less developed' category, but most falling somewhere in the middle of the development scale. Countries in this middle range will attain the development pace of the leaders in the region probably only after considerable time.

Technological development correlates rather reliably with achievement in the nuclear field: where industry and technology are broadly developed, so is the country's nuclear technological base. It is not surprising, therefore, that in the Latin American region, nuclear programmes of various types – including commercial-scale power generation – are well advanced in Argentina, Brazil and Mexico. Brazil's Angra I power station, for example, is already producing electricity on a commercial scale. Work on the construction of other nuclear power plants is well under way in all three countries. It is in such advanced developing countries that technical co-operation in the sense of self-assistance and collaboration is most apparent. The description of one recent project undertaken in Brazil illustrates this point.

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Expertise under one roof

Some ten years ago, the Government of Brazil requested assistance from the United Nations Development Programme (UNDP) for the Centro de Energia Nuclear na Agricultura (CENA), to promote the application of nuclear techniques in agriculture. The Brazilian Government recognized the potential usefulness of a centre at which facilities and expertise would be 'under one roof', but before the CENA was set up no single national institute specialized in such applications.

Although Brazil then had numerous well-trained scientists, and nuclear methods were being used to some extent, expertise and facilities were dispersed throughout the country. CENA was set up in Piracicaba, as an affiliate of the University of São Paulo, to co-ordinate such activities. In approaching UNDP, the Government sought to obtain assistance in procuring both necessary laboratory equipment and the advice of international experts in specialized areas pertaining to actual agricultural production problems. The original project request, approved in 1972, included provisions for international experts, equipment, and training for local staff through fellowships and scientific visits. For its part, the Government agreed to supply buildings, land, equipment, and counterpart staff for the project. Although originally the project had been scheduled to terminate in 1978, UNDP assistance continued through a second phase before concluding in 1981. From 1979, supplementary assistance was also provided under the Agency's regular programme, and some support is still being supplied. A breakdown of expenditures for the project is given in the Table on page 18.

What is evident from these figures is that the contribution by the Government of Brazil*, even excluding almost 10000 man-months of work by national staff, significantly exceeded the international contribution. International co-operation thus served to supplement an essentially national programme. Management of the project was accomplished jointly by CENA's Director

* In particular through the Brazilian Nuclear Energy Commission (CNEN) under the agreement between CNEN and the University of São Paulo.

Expenditures for the CENA project 1972–1981

Source	Equipment (US $)	Experts	Training	Local			Total (US $)
				Professional staff	Support staff	Buildings and land (US $)	
UNDP	804 999	216.3	207.8	–	–	–	2 010 878
IAEA	42 637	17	10*	–	–	–	143 734
Governmental	1 514 700	–	–	4533	5013	1 277 400	2 792 100**
Total	2 362 336	233.3	217.8	4533	5013	1 277 400	4 946 712**

Figures for experts, training, and for local professional and support staff are expressed in man-months.

* Estimated.

** Excludes the value of national staff made available to the project.

and the international Project Manager, the latter acting in an advisory capacity and also as the liaison officer between the Government and the Agency. The specific research programmes for which international expert services were sought were, in large part, drawn up and executed by counterpart staff. This national approach to implementing nuclear technology has thus served both to develop CENA's scientific independence and to keep research focused on practical agricultural problems.

Self-sufficient research

In addition to meeting its original objective of establishing a comprehensive centre for nuclear applications in agriculture, the project has attained a high degree of self-sufficiency. Its staff is fully capable not only of applying existing nuclear techniques, but also of developing new ones and integrating them into useful, practical programmes. For example, useful work has been done in exploration of water resources in the Amazon region; genetic improvement of basic food crops (e.g. beans, rice, and wheat); food preservation; fertilizer use and efficiency; plant and animal nutrition; and animal parasitology. Activities that illustrate the main lines of research are outlined below.

Fertilizers and soil fertility: Considerable progress has been made in studies on soil organic matter, and investigations are under way on the effect of vinhaça (liquid waste from sugar refining) on soil microflora. Labelled fertilizers have been used to determine best management practices for efficient fertilizer use. With ^{15}N, measurements of nitrogen fixation in both leguminous and non-leguminous crops are now in progress. Laboratory studies have been completed on the assessment of soil zinc and manganese available to *Phaseolus* (beans), and analytical methods for total Zn and Mg have been worked out.

Soil microbiology: As it was possible to increase laboratory space for soil microbiology, adequate facilities now exist for culture transfer and media preparation. In studies on Phaseolus, it was discovered that peak nitrogenase activity during plant development occurs before the greatest absorption of nitrate, as reflected by nitrate reductase activity. Other work showed that radiation-sterilized peat has the greatest capacity for promoting growth of *Rhizobium* (nitrogen-fixing) cultures. An international workshop on associative dinitrogen fixation was held in 1979 and the proceedings published.

Plant biochemistry: Work in this field has concentrated on protein investigations and plant tissue culture. With Phaseolus, analyses have been made of protein and amino acid content in the seed of various lines. In rice, work is continuing on the determination of characteristic fractions of seed protein and protein levels in different cultivars. Tissue culture work has concentrated on the regeneration of sugar-cane plantlets from callus, and a routine method has now been established. Efforts to culture Phaseolus embryos are continuing, and recently obtained results suggest a favourable outcome; this work ought to permit the utilization of wide Phaseolus crosses that would normally not yield viable plants. An international course on plant tissue culture for the improvement of tropical crops was held in October 1980.

Entomology: Studies in entomology have concerned stored grain insect pests, the use of radiation for grain disinfestation and the ecology of the Mediterranean fruit-fly (medfly). Also investigated was the sugar-cane pest *Diatraea saccharalis;* this work indicated that minimum insecticidal control at the critical period could result in yield increases of approximately 10% – an important finding.

Plant breeding and genetics: Induced mutation experiments have been made on wheat, rice, sorghum, sugar-cane, and on Phaseolus with the overall aim of obtaining higher-yielding varieties. Investigations on wheat have focused on determining the genetic basis for short stems and for stem-rust resistance and on obtaining early-maturing mutants. Rice research has centred on identifying dry-land varieties with tolerance to aluminium toxicity and on the efficacy of sodium azide in comparison with gamma rays as a mutagenic agent. Efforts are being made to obtain varieties of sugar-cane and Phaseolus with resistance to mosaic virus. A national course on mutation plant breeding was held in September 1980.

Animal science: The first achievement was the establishment of well-equipped laboratories and an animal house. Work is progressing on the development of a radiation-attenuated vaccine against lungworm in cattle, and animal trials are under way. As regards animal nutrition, investigations have concerned the effects of dietary phosphorus on sheep and cattle. A project on the use of sugar-cane waste products in animal feeds will soon be started. In general, work at CENA in animal science over the last few years has been characterized by excellent co-operation with the Instituto de Zootêcnica in Nova Odessa.

Electron microscopy: Studies are continuing on a bacteriophage of *Xanthomonas campestris,* (a pathogen for the tomato): the principal life-cycle stages have been reconstructed. Work on the action of Viramide on the NPV virus, which affects silkworms, has been completed, and research is now focused on the action of glyphosphate, a herbicide, on sugar-cane varieties.

Instrumentation group: This unit has been working on growth-ring/climate relationships and the determination of water flux in wood using gamma-ray techniques. An automatic scanning system, which includes computer-based data storage and analysis, has been developed for growth-ring identification.

Soil physics: Main interests are nitrogen transport and transformation in soil, including nitrogen-compound dynamics and their relationship to water movement. These topics, together with the efficiency of use of water, have been studied in connection with beans, maize, and sugar-cane.

Hydrology/ecology: The hydrology of the Amazon Basin is receiving world-wide attention in view of the possible ecological consequences of deforestation. CENA is collaborating with the Instituto Nacional de Pesquisa Amazônia (INPA) in Manaus on investigations of the water, carbon dioxide and nitrogen cycles, and it is expected that this work will yield important results. Recent findings indicate that a large proportion of the rainfall in the region (48%) is recycled. This could mean that extensive clearance of trees might considerably affect the microclimate. In addition, river-pollution studies, with special reference to the Piracicaba River, are being undertaken to develop methods of control using soil-vermiculite mixtures.

Analytical chemistry: The analytical laboratory has become a focal point of many programmes, both for CENA and its collaborators. The laboratory performs thousands of analyses of plant, soil, and water samples annually in support of various research programmes. Particular expertise has been acquired in flow-injection analysis, and CENA is now regarded as a world authority in this area. The laboratory received considerable support in the first phase of the project from the Danish International Development Authority.

A model for other centres?

Over the last ten years CENA has developed from a small, rather poorly-equipped national research institute to a major international centre for agricultural research at which a great variety of advanced and important investigations are being undertaken. In view of the short time CENA has been in existence, this is a remarkable achievement. One index of the level of expertise at the Centre is that its senior staff members now often serve as experts on international projects. As a specialized institute of the University of São Paulo, CENA also maintains a strong educational role at both undergraduate and postgraduate levels. Usually over 40 students are enrolled in different stages of its three-year undergraduate course and more than 50 persons attend the two-year postgraduate course 'Nuclear energy in agriculture'. Fellows from other countries in the region also undertake advanced studies at CENA. For all practical purposes therefore CENA has become self-sufficient. This is a notable and not altogether common achievement in the developing world. While it is true that the governmental contribution towards its establishment significantly exceeded the support received from international sources, the latter were crucial to permitting such a rapid pace of development.

Some national regulations pertaining to the disbursement of foreign currency could, for example, be bypassed, enabling equipment and the services of international experts to be obtained more expeditiously than would otherwise have been the case. It is largely for this reason that small-scale assistance is still being provided to CENA under the Agency's regular programme.

Collaboration with other institutions has marked CENA's activities from the very outset. During the fourteen years of the Centre's existence contacts have been established with more than 40 institutions in Brazil and abroad, and there has been significant interchange with many of these. Continuous contacts are,

for instance, maintained with INPA in Manaus, IDESP* in Belém, Planalçúcar**, various EMBRAPA*** centres, CATI****, the Instituto Agronômico in Campinas and in Londrina, the Instituto de Zootêcnica in Nova Odessa, and CIAT***** in Colombia.

At the international level, in addition to the several research contacts and agreements held with the Agency, CENA frequently hosts various regional and interregional meetings and workshops. Furthermore, some of the fellowship training provided at CENA is arranged through bilateral agreements with other countries.

In fulfilling its initial objectives, CENA's leaders were conscious of the need for co-ordinated development in building up the various groups and laboratories. CENA's requests for assistance clearly show this approach, with experts' terms of reference, for example, gradually becoming more specialized and tied to particular investigations or special aspects thereof. Collaboration with other institutions, which now characterizes many of CENA's activities, was seen as essential so as to keep the Centre's work problem-oriented, to minimize duplication of efforts, and to accelerate the pace of research on various problems. These factors, viewed collectively, have been responsible for the success of the project thus far.

While conditions are sometimes very different in other developing countries, and although the financial and manpower resources that were available for CENA's establishment may not always be at hand, the general course being pursued by the Brazilian Government and the Centre is sound, and certainly deserves consideration, if not emulation, by centres in other countries.

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*** Empresa Brasileira de Pesquisa Agropecuaria.

**** Coordenadoria de Assistência Técnica e Informação.

***** Centro Internacional de Agricultura Tropical, Cali.