Improving food and agricultural production in Thailand

An extensive co-operative project uses isotopes, radiation, and related techniques to study some traditional problems

by Patoom Snitwongse and Carl G. Lamm

In the early 1960s, the IAEA and FAO jointly initiated the first in a series of large-scale multi-faceted agricultural field projects using nuclear techniques in agricultural sciences. The first project, in Yugoslavia, served as a model for future ones in India, Brazil, Bangladesh, Republic of Korea, Venezuela, and Thailand. All were principally funded by the United Nations Development Programme (UNDP); those in India and Bangladesh also drew support from the Swedish International Development Authority (SIDA).

The Thailand project — for the time being the last one of this series — stands among the most extensive and technically complex, encompassing some 60 specific organizational and scientific tasks through field studies, experiments, and other activities. *(See accompanying map.)* Traditional problems of soil fertility, water supply, and animal health are among those that project scientists are tackling with the help of nuclear techniques and methods. Started in January 1986 for a 5-year period, the project carries major objectives centering on the use of isotopes, radiation, and related technologies in three particular areas:

- *Mutation breeding.* Scientists are aiming to generate new genetic sources of disease-resistant varieties of crops that are economically important.
- *Soil science.* Aims are to help farmers make the best use of fertilizers, biofertilizers, and water, and to maximize biological nitrogen fixation and the use of local rock phosphates as sources of crop nutrients.
- *Animal science.* Project scientists are aiming to improve livestock productivity on small farms.

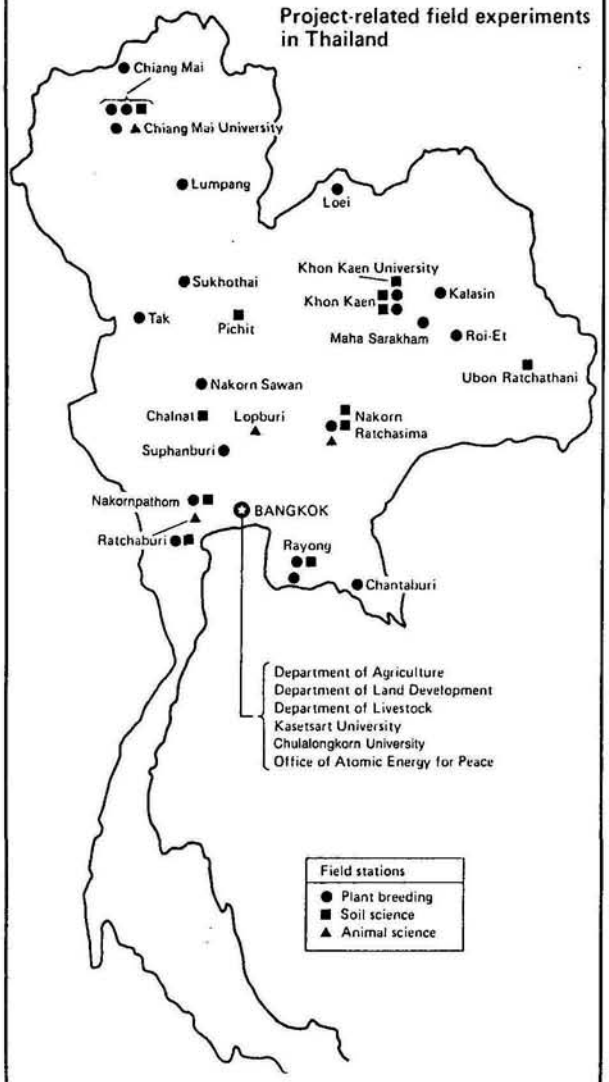
Most project funds come from the UNDP, which is providing about US $1.4 million for expert costs and US $536 400 for fellowship training and purchases of specialized equipment and supplies. Support from the Government of Thailand amounts to more than 111 million Baht.

Mrs Patoom Snitwongse is Head, Nuclear Research in Agriculture, Agricultural Chemistry Division, Department of Agriculture, Bangkok. Dr Lamm is Chief Technical Advisor for the IAEA/UNDP/Thailand project (85/004) and a former Deputy Director of the Joint FAO/IAEA Division.

Mutation breeding

Plant breeders have long used radiation techniques and chemical agents to induce desirable properties in crops or plants. In Thailand, scientists are searching for more disease-resistant food legumes, fibre crops, cereal grains, oil crops, and vegetatively propagated crops. Among the tasks, germ plasm and induced mutants are being screened for resistance to a number of plant diseases. Techniques are being strengthened in combination with a FAO/IAEA technical co-operation project through establishment of an *in-vitro* and mutation breeding service at the Thailand Department of Agriculture's

Researchers preparing isotope microplots in studies of rice fertilization in Thailand.



Started in January 1986, the Thailand project today encompasses experiments being carried out at 32 field stations in 20 Thai provinces, and veterinary surveys at small farms in more than 100 villages. Other studies are under way at experimental installations — laboratories, greenhouses, livestock sheds, and fields — at the headquarters of the eight participating Thai institutions: Department of Agriculture; Department of Land Development; Department of Livestock; Kasetsart University; Khon Kaen University; Chiang Mai University; Chulalongkorn University; and the Office of Atomic Energy for Peace (OAEP). Additional technical support is provided by the IAEA and Food and Agriculture Organization (FAO) through their Joint Division headquartered in Vienna, Austria, and its allied Laboratory in Seibersdorf, Austria, outside Vienna. The project's administrative headquarters are at the Central Services Unit, located at the Thailand Department of Agriculture's Laboratory of Nuclear Research. Already equipped to undertake analyses and training in isotope measurements, particularly nitrogen-15, the unit is now installing a mass spectrometer — the first in Thailand — to expand research capabilities. By co-ordinating the project with several related international and bilateral activities in Thailand, other resources and expertise have also become available.

Division of Plant Pathology and Microbiology. Consisting of a greenhouse and a laboratory, this unit will offer training and services to other institutions.

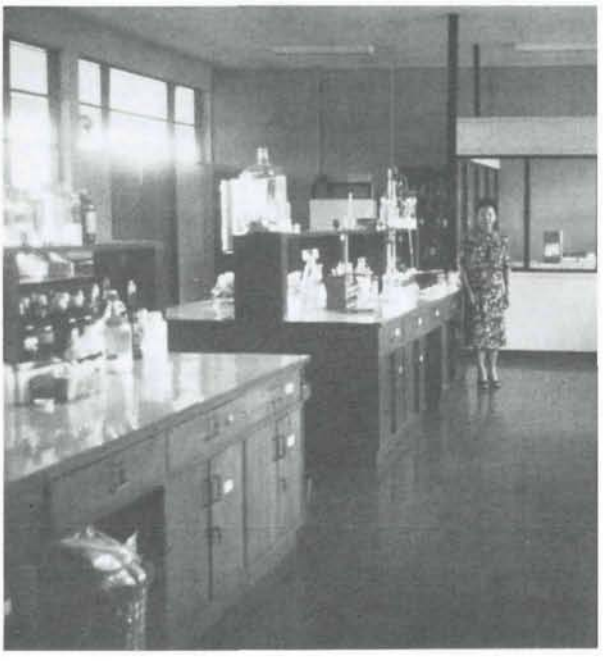
To foster exchange of scientific information and research results, a National Mutation Breeding Workshop was held during December 1986, attracting over 70 scientists. Some promising mutants of crop species that are resistant or tolerant of specific diseases already have been obtained, and these are being tested in field trials — for example, soybean that is more resistant to rust. Mutation induction has started on other crop species, such as yardlong bean, cow pea, castor bean, and sugar cane.

Soil science

How efficiently crops use fertilizers, or how to improve the amount of nutrients they can derive from the soil, are some of the important questions being studied. Some specific activities are devoted to development of management practices for better use of artificial and natural fertilizers and water. Toward the end of 1987, a national training course was held on soil-water-plant relationship studies. *(See accompanying box for an overview of research on soil-water-plant relationships under the project.)*

Scientists are especially studying the fate and efficiency of fertilizer nitrogen in acid-sulphate soils. Different sources labelled with nitrogen-15 are being used, with emphasis on rice, maize, and vegetable crops. One important finding was that, in some soils, significant quantities of fertilizer nitrogen were immobilized in the soil's top layer (30 centimetre depth), and

One of the laboratories in Thailand's Central Services Facility, which serves as the project's administrative centre.



that the crops could recover from 76-87% of it; nitrogen losses were between 12-24%. Also being studied is the utilization of Thai rock phosphates on different acid-sulphate soils. Results so far demonstrate their practical use for rice in soil with a pH value below 4.

Studies of biological nitrogen fixation using nitrogen-15, which have been increasingly emphasized over the years, have now reached a stage where farmers can apply practical results: Soybean can be grown commercially with minimum use of nitrogen fertilizers by selecting proper varieties, using *Rhizobium japonicum* strains selected for maximum biological nitrogen fixation, and by applying improved crop management practices.

Animal science

Project activities concerned with improving animal productivity mainly emphasize the application of immunoassays for determination of progesterone (a reproductive hormone) in cattle and buffalo. Work also includes veterinary surveys at small farms and provision of an analytical quality control service through Chulalongkorn University. Laboratory and field work now centered there is being transferred to three other universities so that more of the country's livestock can be reached. Reproductive patterns of dairy cattle and swamp buffalo at small farms and in larger herds are being assessed to establish correlations between reproductive performance and progesterone tests.

Studies are planned to develop radiation-attenuated vaccines against parasitic diseases — specifically, the Liver Fluke disease, one of the most important parasitic pests afflicting livestock in Thailand. Epidemiological studies are being intensified of the disease's prevalence and its effect on productivity and work capacity of buffalo and cattle as a prerequisite to a possible vaccination campaign.

Soil, water, and plant productivity

by Klaus Reichardt

In Thailand, water and fertilizer economy in field crops is an important issue in improving agricultural production, mainly in the northeastern and eastern areas where sandy soils prevail. These soils have low fertility and an extremely low capacity for holding water, but they are of great importance for food production. Knowledge of water regimes, crop water uses, root distributions, water retention characteristics, and fertilizer leaching, under different cropping conditions, will therefore contribute toward adoption of more rational management practices and, ultimately, improved crop productivity.

The country's Department of Land Development is establishing several field experiments and pilot projects using nuclear technology to assess the water content and bulk densities of soils, and fertilizer loss by leaching. Results of these trials will immediately be transferred to farmers through, for example, the Khonkaen Cholburi and Rayon Rainfed Agricultural Pilot Projects, where farmers apply concepts of soil and water conservation through the guide of professionals from the Department of Land Development.

Nuclear tools and techniques can play an important role. Suitably calibrated neutron probes can be used to measure soil water content at different depths in the soil profile, and at different time intervals, during the entire crop cycle. With this information, it is possible to study soil water storage, fluctuations during the growing season, and to analyse periods of water shortage and excess at various times in the crop's development. Together with rainfall data, it is possible to estimate crop water requirements, root distribution patterns, and periods when fertilizers have a high probability of leaching.

In the Thailand project, water regimes of several crops — rice, cotton, maize, sorghum, and soybeans, for example — are being studied under different cropping conditions. Although the total amount of rainfall is more than sufficient for rainfed agriculture, its distribution is erratic and the rainy season allows only the cultivation of one crop. Dry spells of one or two weeks within the rainy season severely affect productivity because the soils have a low capacity for retaining water. Root distributions are generally shallow, which also diminishes the availability of water and fertilizer. Common heavy rains, several times depositing more than 50 millimetres, cause nutrient leaching, mainly of costly chemical fertilizer. Erosion is also a problem.

Suitably calibrated gamma probes can be used to measure soil bulk density distributions in soil profiles. The diagnosis of compaction layers that impede root growth is made from these density profiles.

The use of fertilizer labelled with nitrogen-15 allows estimation of the efficiency by which the crop uses fertilizer and how much is leached. Labelling organic matter opens the possibility of studying the fertilizer's rate of decomposition in the soil and its fate in the biological cycle in which the crop develops.

Many soil and water conservation practices are being tested in field trials. Some of these experiments evaluate the effects of compost, green manure, and other materials on increasing the soil's water retention characteristics, promoting a deeper root distribution, and supplying nutrients to crops. Different soil tillage methods are being tested for different soils, slopes, and crops to find management practices that conserve the soil, optimize their water economy, and promote extension of the growing season so that more than one crop can be cultivated.

Prof. Reichardt, a former FAO/IAEA staff member, is full professor at the University of São Paulo at Piracicaba, Centro de Energia Nuclear na Agricultura, in Brazil. In November 1986, he served as an FAO/IAEA expert for the Thailand project.

Strong tradition

Nuclear techniques applied to the solution of practical agricultural problems have strong tradition in Thailand. It began shortly after 1955, when two recommended rice varieties were irradiated in the United States to induce mutations having better grain quality and disease resistance. As a result, three improved mutant rice varieties were released in Thailand during the mid-1960s. Later, work on improvement of food legumes, Thai Kenaf, soybean, jute, cotton, and sugar cane was initiated using gamma irradiation and, as being done today, with related tissue culture techniques.

The Department of Agriculture established a Radioisotope Laboratory in its Chemistry Section in 1959, and phosphorus-32 was used to evaluate the nutrient's utilization in rice and soybean. As was the case with the early mutation breeding work, the soil-plant studies later became part of a number of co-ordinated research programmes of the IAEA and Food and Agriculture Organization following establishment of the Joint FAO/IAEA Division in 1964. From 1962-74, many field experiments at the Surin, Rangist, and Bangkhen Rice Experimental Stations were carried out using phosphorus-32 and nitrogen-15 to assess the efficient utilization of phosphate and nitrogen fertilizers. Isotope-aided research was also conducted on micronutrients, utilization of naturally occurring rock phosphates, and on fertilizer efficiency in other crops.

The Thai Government recognized early the importance of reproductive hormone analyses by radioimmunoassay (RIA), or by the related enzyme immunoassay, for studies of livestock health and reproduction. The analyses were used for early pregnancy testing, oestrous synchronization, and improving management strategies to accelerate puberty and reduce post-partum periods of anoestrus in livestock. The focal point for this work has been Chulalongkorn University. Other research activities have focused on the safe and efficient use of pesticides, and on the application of food irradiation processing to preserve foodstuffs. Throughout the past 20 years, Thai scientists have received specialized training through FAO/IAEA's fellowship programme and training courses in these and other fields.

In 1964, scientists conducted the first isotope-aided experiment in Thailand on rice fertilization.

Buffalo and other livestock can be studied using nuclear techniques to improve their reproductive efficiency.

The isotope phosphorus-32 being used in root distribution studies in Thailand.