Crop Improvement Projects in Peru

by Hans Broeshart

Only two percent of the territory of Peru consists of arable land. Sixteen million people depend on the production of about three million hectares of land, which means that on the average only 1800 square metres is available per person. It is clear that Peru is one of the poorest countries of the world as far as available arable land is concerned and consequently it will have to drastically increase its agricultural production per unit area or import large quantities of agricultural products to feed its rapidly growing population.

In the past, agriculture in Peru was dominated by large estates owned by a small fraction of the population. After the 1968 agricultural reform, most of the land was redistributed and the formation of co-operative farms was stimulated. For the agricultural reform to be successful it was necessary to intensify agricultural research to find the means of economically increasing crop production per unit area and to establish extension programmes for communicating the results of this agricultural research to the farmers.

The FAO with the assistance of various funding agencies has assisted in the organization and development of the research and extension programmes. In co-operation with the Ministry of Nutrition, the FAO since 1973 has been carrying out demonstration trials on the use of fertilizers in farmers' fields and has been involved in the training of instructors, demonstrators and technicians. A system was developed to acquaint the farmer with the latest results of agricultural research and to introduce appropriate cultural methods. The Ministry of Nutrition has prepared and published manuals for field instructors on fertilizer recommendations for most Peruvian crops, as well as instruction manuals for demonstration and training purposes.

The agricultural reform together with the FAO-sponsored programme on the efficient use of fertilizers have led to an increase in agricultural production due to an increased application of fertilizers and the use of methods of application which were developed in agricultural research centres and universities.

Table 1 illustrates the rapid increase in fertilizer use since 1968, and in particular, during the period 1973–77.

Isotopes and Radiation Techniques

Agricultural research on the efficient use of fertilizers is being carried out by the regional experiment station (CRIA), by the National University of Agriculture, La Molina, Lima, dealing with programmes on maize, potatoes, cereals and forage crops, by national universities in the country and by specialized research institutes for tropical agriculture on sugar-cane, cotton, coffee and tea.

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Isotope and radiation techniques are a particularly effective means of determining the best cultural practices for the efficient use of fertilizers and water, and the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture has been involved in the organization of field and greenhouse programmes at experiment stations and universities in Peru since 1963.

It is well known that crop production can be greatly increased through the application of nitrogen (N), phosphorus (P) and potassium (K) fertilizers. Unfortunately the high cost of these fertilizers, which to a large extent have to be imported into Peru, makes them prohibitive for extensive use. Research institutes have therefore been confronted with the problem of how to obtain the highest yield with a minimum of fertilizers. Fertilizers should be applied in such a way that the crop is able to take up a maximum from the fertilizer and at the same time fertilizer losses due to fixation, microbiological transformation, gaseous loss and leaching from the rooting zone should be reduced to a minimum. This means that, for each type of crop and depending on soil type and climate, appropriate methods of placement and timing of the fertilizer application have to be determined. Moreover, different chemical forms of the fertilizer compounds must be evaluated for the different soil types.

Before 1954, the experimental approach was only possible by means of *indirect* methods, i.e. by comparing yield and total nutrient content of crops subjected to different fertilizer

Table 1. Fertilizer consumption in Peru

Period	N	P_2O_5	K_2O	Total
	(in 1000 tonnes of fertilizer element)			
1951–56	50.4	28.4	7.8	86.6
1956–58	50.0	32.7	7.8	81.5
1958–60	42.3	15.2	4.7	62.2
1960–62	59.7	18.3	4.4.	82.4
1962–64	65.2	22.5	4.7	92.4
1964–66	66.4	19.2	4.1	89.7
1966–68	59.5	9.6	4.3	73.4
1968–70	62.9	9.0	5.4	77.3
1970–72	76.5	9.4	5.6	91.5
1972–74	75.3	12.0	6.8	94.1
1974–76	84.8	13.6	9.5	107.9
1975	83.5	11.7	9.5	105.9
1976	100.3	17.0	11.5	128.9

practices. Nowadays it is possible to *directly* determine quantitatively the fraction and amount of an element in the plant derived from fertilizers and from soil by using isotopically labelled fertilizers. Thus, various management factors can be compared and quantitative information obtained.

Results of Immediate Practical Interest

Contrary to the opinion of some that isotope techniques are the domain of the isolated scientist working on problems of academic interest, the results obtained by the Joint FAO/IAEA Division's programme in Peru may serve to illustrate their immediate practical importance.

During the period 1963–68, a co-ordinated research contract programme on the efficient use of fertilizers by maize was carried out in a number of countries, including Peru. Table 2 gives an example of results obtained from comparisons of placement and timing of nitrogen fertilizer which was labelled with nitrogen-15. The data, which are valid for the irrigated soils of the coastal desert of Peru, clearly show that the efficiency of utilization can be greatly improved when the nitrogen fertilizers are placed in a band instead of being broadcast on the surface. Moreover, an increase in efficiency could be obtained by timing of a portion of the fertilizer so that it is applied when the plants reach a height of 40–50 cm. These research results were obtained at the CRIA Experimental Station, La Molina, Lima.

Within the framework of a Technical Assistance programme carried out during the period 1976–77, country-wide investigations using superphosphate labelled with phosphorus-32 were carried out by professors and graduate students of the national agricultural universities of Lima, Huancayo and Cajamarca, and by the scientific staff of regional CRIA experiment stations in Lima, Cuzco, Cajamarca and Huarez. One objective of the programme was to

Table 2. The uptake of fertilizer nitrogen by maize in kg N/hectare

Method and times of application of ammonium sulfate	kg N/ha of fertilizer N taken up by maize	
	from application of 100 kg N/ha (1964/65)	from application of 80 kg N/ha (1965/66)
Surface broadcast and ploughed down	26 (25%)	18 (22%)
In band, 5 cm from plant row	36 (36%)	30 (38%)
At plant height of 30 cm	27 (27%)	–
At plant height of 40 cm	–	37 (46%)
At plant height of 50 cm	–	38 (48%)
At tasseling time	–	33 (41%)
10 days after tasseling	–	20 (25%)

find out to which extent locally available Bayovar rock phosphate could be applied to different Peruvian soil types, and at the same time to make a quantitative comparison of the availability of phosphorus derived from the local Bayovar rock phosphate with phosphate sources such as Florida rock, triple super and ammonium phosphate which have to be imported at a high cost.

Table 3 illustrates a typical example of the results that were obtained from experiments using superphosphate as a standard of comparison. The table shows that on acid soils the utilization by crops of the phosphorus from Peruvian Bayovar is very good and much better than from imported Florida rock phosphate.

The decision whether to use locally available Bayovar rock phosphate instead of imported phosphate fertilizers will depend on the price of the fertilizer at the site where it is to be applied. Since the price will be dependent on transport costs, etc., it will be possible to make the best recommendation for a particular area using the type of quantitative comparison shown in Table 3. Such data is extremely useful for instructors involved in agricultural extension work who have to give advice on local fertilizer use.

Isotope Research Programmes

It should be emphasized that this use of isotope techniques enables the investigator to "ask" the crop which fertilizer will supply more phosphorus to its roots and how much of it is actually taken up by the plant

The Peruvian Institute for Atomic Energy (IPEN) recognized the importance of isotope and radiation techniques for solving problems of practical interest in the fields of soils and fertilizers, animal production and plant breeding Within the framework of an agreement

Table 3. Comparison of local Bayovar rock phosphate with imported fertilizer sources

Kg P in the form of phosphate fertilizer necessary to supply the equivalent of 1 kg P as superphosphate

Location of soil type	Source of phosphate fertilizer				
	Bayovar Bruta	Bayovar Concentrada	Florida Rock	Triple Super	Ammonium Phosphate
Aeropuerto Sierra pH 7.3	2.7	0.0	5.3	0.6	0.6
Sta. Rosa Sierra pH 5.3	1.5	9.0	3.6	0.4	0.5
Huanchas Sierra pH 6.1	1.1	1.8	5.3	0.6	0 4
Villa Rica Selva Alta pH 6.9	4.7	7.3	7.3	1.1	1.7

with the National University of Agriculture, La Molina, Lima, an isotope programme was initiated in 1976 including the installation of laboratory facilities for training and research in the field of agriculture.

The agricultural programme is presently receiving additional support from the IAEA's Regular Programme of Technical Assistance. This is expected to be greatly expanded in 1979 by support from UN development funds for a national programme on the use of atomic energy in many different disciplines, including medicine, agriculture and industry.

The current and future investigations in Peru on the efficient use of fertilizers and water are directed toward specific problems in three regions of entirely different geological and climatic conditions.

Along the Pacific coast, the so-called "Costa", rainfall is absent, but a number of rivers run from the mountains to the Pacific through this desert region and form oases with abundant agriculture. Although the "Costa" represents only 30% of the total cultivated area of the country, it produces 55% of the agricultural products of Peru.

In the northern part of the Costa, maize, rice and sugar-cane are the most important crops, in the central and southern part the major crops are alfalfa, maize, cotton and fruits. The soils generally lack nitrogen and sometimes phosphorus. Water is the main limiting factor and agriculture is only possible when irrigation water is available. Frequently soils have salinity problems because of bad drainage. Both toxicity and low availability of micro-elements are frequently problems on the calcareous soils of high pH.

The land inward, parallel to the Costa, is the Sierra, chains of mountains of the Andes with an altitude of 1000–6000 metres. Most of Peru's rural population lives in the valleys and plains of the Sierra and their agricultural practices are frequently very primitive. The types of soil and climatic conditions vary greatly within relatively short distances, and with altitude. The climate is characterized by high day temperatures, and low night temperatures; rainfall is irregular and agriculture suffers from extended dry periods and sudden changes in temperature. It is estimated that only 100 000 of the 1.7 million hectares of arable land in the Sierra can be irrigated. The Sierra soils are deficient in nitrogen and phosphorus and the production of the most important crops such as potatoes, maize, barley and wheat is extremely low. The road system is poor, particularly in the rainy season and consequently the cost of transport of fertilizer and agricultural products is high.

The sub-tropical and tropical parts of Peru are found on the eastern slopes of the Andes and in the Amazone plain. This area is called the Selva. The sub-tropical part, the "Selva Alta", has soils of rather low fertility in which nitrogen and phosphorus are frequently deficient. A relatively small part of the Selva Alta is being cultivated, about 400 000 hectares, mainly with tree crops such as coffee, papayas and avocados and yields are frequently low.

In the tropical rain forest, the "Selva Baja", agricultural development is just starting. The soils are extremely poor in plant nutrients and often suffer from bad drainage. High cost of fertilizers and transportation seriously limit agricultural production in the lower Selva.

Support of FAO and IAEA

Both organizations have realized that efficient use of fertilizers by applying them in appropriate places at appropriate times and in the correct chemical form is of primary importance for the farmers in Peru. Researchers at Peruvian experiment stations and agricultural universities are presently using isotope techniques because they recognize that they can thus make a direct quantitative evaluation of cultural practices leading to the most economic use of fertilizers for a particular location.

The Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture continues to help in the development and carrying out of research programmes by Peruvian research institutes and universities within the framework of co-ordinated research contracts, and training and technical assistance programmes to ensure that essential practical information which has a direct impact on fertilization and irrigation practices in Peru be made available to those involved in agricultural extension work.