Photo: IDRC

By FAWZY KISHK and ROBERT CHARBONNEAU

Fernando tills his field in Colombia. The land, as in most of tropical Latin America, is infertile and acid. Thousands of kilometres away in North Africa, another farmer, Mustafa, is getting ready to plant his beans in the sandy calcareous, and mostly alkaline, soils of northern Egypt. He too has a tiny plot of land.

Both men are poor, subsistence farmers and really cannot afford expensive inputs such as fertilizers. But they have no choice. Like millions of peasants around the world, they must add fertilizers to their soil if they hope for a decent harvest to make a little profit or break even.

Mustafa and Fernando have heard from the extension specialists that plants need several elements. They know about nitrogen, potassium, and phosphorus as elements often added to the soil to maintain soil fertility and to improve productivity. Crops drain the soil of potassium, but it is in abundance in their soils and seldom represents a problem.

The extension specialists have also told them that nitrogen is found in nature in unlimited amounts. Some crops such as legumes recycle atmospheric nitrogen. But it is phosphorus that is the most limiting essential element under their soil conditions.

Worldwide reserves of phosphates (phosphorus rich compounds) are limited. If they continue to be used at the present rate they will not last more than 600 years. They constitute a valuable, nonrenewable resource. There are rock phosphate deposits in many parts of the world—in Colombia, Brazil, Peru, and Venezuela in Latin America, and in Morocco, Togo, Senegal, Tanzania, and Upper Volta in Africa.

The major exporting countries, such as Morocco, are aware of the fact that deposits are wearing thin and the cost of exploitation is rising steeply.

Rock phosphates are converted into soluble phosphatic fertilizers, such as superphosphate, through industrial processing. The cost of such fertilizers can be prohibitively expensive for a small farmer such as Fernando or Mustafa. But peasants cannot do without phosphate fertilizers. Every time they prepare the land for planting, they apply fertilizer, which seems to disappear as if by magic, leaving little or no residual effect for the next crop.

FERNANDO'S DILEMMA

Fernando's soil is infertile and lacks phosphorus in a form his plants can use. He therefore applies phosphate fertilizer to this strongly acid soil but unfortunately the added phosphorus quickly disappears. Where does it go?

The problem is that tropical acid soils contain large percentages of certain iron and aluminium oxides. These react with phosphorus, fixing it in a form not readily available to the plants. The more of this expensive fertilizer Fernando adds, the more he loses. His soil is like a bottomless pit. Could he have used an alternative cheaper source of phosphate, one that does not vanish as quickly from the soil?

This question is the subject of IDRC-supported research being undertaken by the International Centre for Tropical Agriculture (CIAT) in Colombia and the International Fertilizer Development Center (IFDC) in the USA. Researchers at both institutions are exploring ways of developing less expensive phosphorus sources, such as the direct application of rock phosphates to the soil.

The hypothesis is simple: since rock phosphates are converted by manufacturers into soluble phosphatic fertilizers by acidification, it follows that the excess acids in the soil should have the same effect on the rock. The strong acidity of the tropical soil can thus be used to slowly dissolve crushed rock phosphates and gradually release phosphorus for use by plants. This slow release could have a long-lasting effect on the soil, since degradation of the rock will continue with time. In Colombia scientists are busy developing an overall phosphorus management strategy for acid soils. It calls for the use of alternative sources of phosphorus suitable for the various cropping systems in the different parts of the country.

THE CASE OF NORTH AFRICA

Near Alexandria, in those arid lands typical of North Africa and the Mediterranean, Mustafa is getting ready, like everyone else, to spread superphosphate on the land. What he may not realize is that his soil, which has been receiving phosphatic fertilizers for many years, may already be saturated with

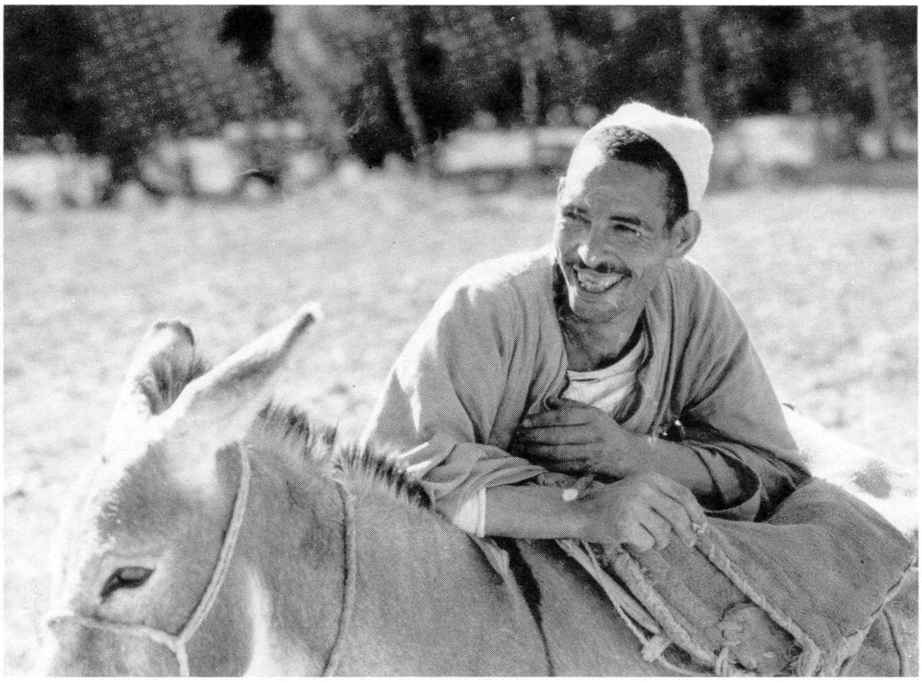

Photo: Neill McKee

IN SEARCH OF LOST FERTILITY

phosphorus. But since Mustafa does not want to take any chances, he buys and uses more fertilizer than he actually needs.

Mustafa has a reason to suspect troubles if he does not apply fertilizer. His soil, being highly calcareous, represents a special problem for phosphorus. As in the case of Fernando's soil, Mustafa's tends to fix the added phosphorus and render it unavailable to plants. The chemical mechanisms, however, are different in each case.

Mustafa is a powerless victim. He is sitting on top of a veritable storehouse of phosphatic fertilizer. He spreads 350 kilograms of superphosphate on each hectare of his land at every harvest. The Egyptian government sells fertilizers to farmers at a subsidized price, but the subsidy applies only to the first 250 kilograms per hectare.

Mustafa is absolutely convinced that the quantity provided to him at the subsidized price is insufficient. Advertising encourages him in this attitude. Better to use a little too much than too little, he reasons.

A few weeks after the superphosphate fertilizers have been spread on the land, they have crystallized because of contact with the alkaline soil (a process different from the one going on in Colombia). Unless plant roots come directly into contact with the phosphate granules, the fertilizer remains inert. In practice, the chances of such contacts are slim. There is therefore little benefit to the plants and Mustafa repeats the operation at each harvest.

Researchers at the University of Alexandria, under the direction of Professors F. Amer and A. Monem Baalba, have been studying this problem. But it isn't easy to find an answer. In Egypt, as in Colombia, it is the soil which is the active element.

In crystal form, superphosphates are insoluble, and hence the phosphorus they contain is not readily available to plants. A large fortune spent by Mustafa has sunk irretrievably into the ground.

In this desert country, where immense efforts are being made to grow crops, some soils consist mainly of infertile coarse sand. This simply compounds the crystallization problem. The phosphates sink in rapidly, beyond the reach of roots. This represents a permanent loss—unless of course the researchers at the University of Alexandria can come up with an answer.

The results of their research, which have been passed on to the Egyptian Ministry of Agriculture, have already demonstrated the absurdity of the situation and the excessive costs involved in this unrestrained use of fertilizers. It isn't economically feasible to evaluate each plot of land, but recommended maximum phosphate levels consistent with maintaining yields and preserving soil fertility have at least been set. In the Nile Valley, where the soil is richer in clay and more fertile, the upper limit is 250 kilograms per hectare. In the desert areas the recommended rate is slightly higher.

Professors Amer and Baalba and their team, with help from IDRC, have begun laboratory research to try to find mixtures that would protect phosphates against rapid crystallization in calcareous soils.

They have discovered that pyrophosphates (pyrophosphoric acid salts), for example, crystallize more slowly and are therefore able to supply the phosphorus requirements of plants for a longer period before becoming inert.

INHIBITING CRYSTALLIZATION

A number of other ways of slowing down or preventing the crystallization of phosphates have also been explored. In a number of industries, special compounds are used to inhibit the formation of crystals (scaling) in boilers. In the pharmaceuticals industry, other products are used to prevent saline eye solutions from crystallizing. Could a way be found to use these or similar substances in agriculture to prevent or slow down the crystallization of phosphorus? Is there an economically practical way of coating superphosphate granules so as to slow down the surface contact with the soil and retard crystallization? In industry it has been easy enough to find ways of countering the phenomenon of crystallization, but an agricultural answer is more complicated because a number of factors act simultaneously in the soil.

The University of Alexandria researchers have experimented with all these ideas. Their research is on the right track and they now know a lot more about the crystallization of phosphates in soil. However, there are still many unanswered questions and more work is needed.

On his little parcel of land, now a treasure trove of unusable phosphates, Mustafa is eager to learn. As for Fernando, thousands of kilometres away, he is impatiently waiting for a cheap phosphate source, such as rock phosphate, to become available on the local market. Then he will be able to make use of the acidity of his land to break down the phosphates. That will enable him to save the cost of expensive imported fertilizers. □

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SOILS: ACID AND ALKALINE

Soils can be classified by their degree of acidity, known as pH. Neutral soils have a pH of 7. Those with a lower pH are acid; those with a higher pH are alkaline.

Most tropical soils are acid. The Amazon Basin, for example, consists almost entirely of oxisols (acid soils contaminated by ferric oxides) or ultisols which are also acid but contain more clay. Acid tropical soils are also common in equatorial Africa.

To combat acidity, farmers add lime. To restore soil fertility they apply superphosphates, which have been processed with acid.

Research at IFDC and CIAT suggests an alternative, namely the use of rock phosphate crushed to dust. This is broken down by the natural acidity of the soil and, in the process, fertilizes the soil. Other possible measures include the selection of plants that tolerate the natural acidity of the soil.

Alkaline soils are generally calcareous, sometimes sandy. These are commonly encountered along the shores of the Mediterranean. To make them more fertile, farmers add superphosphates which, because they have been acidified in manufacture, also help to normalize the pH of the soil.

Farmers also know from experience that manure reduces soil alkalinity, provides essential elements, and improves soil structure.