The maize yields possible in parts of Zaire equal the best in the world. Zaire's new national maize program, led by well trained young Zairians, has developed practices that are giving small farmers spectacular yield increases.

Cover Photo:
Muleba Nyanguila, right is the director of PNM. He and Mossala Makambo recently received master's degrees from Kansas State University. Binsika Bimayala and Mulamba Ngandu Nyindu recently received the M.S. degree from Iowa State University.
Loading a truck which will carry village women and their agricultural products to market.
In 1976, a dozen farmers in Mulungushi, a tiny village in southeastern Zaire, harvested 6000 kilograms of maize a hectare—a yield that would be respectable for any maize farmer. These farmers were participating in a supervised credit scheme organized by the national maize program of Zaire. The scheme aims at debunking some widely held ideas about Zaire: that the soils and environment condemn maize to low yields and that, even if ways to improve maize productivity could be found, the farmer is somehow uninterested in new ideas and better livelihoods.

The scheme has been in operation for 3 years in villages scattered over an area the size of Spain. The results are illuminating. In 1973/74, 15 farmers participated. Their maize yields averaged 5100 kg/ha. In 1974/75, 146 participants averaged 3200 kg/ha. In 1975/76, 168 participants averaged 4700 kg/ha. The neighbors of participating maize growers had yields of 1,000 to 1,500 kg/ha.

The results of the credit scheme underscore two important points. First, during its short existence, the national maize program has developed varieties and found practices that can double and triple the yields of Zaire’s maize growers. Second, the typical maize farmer, lacking cash, poorly educated, equipped with only a short-handled hoe, is eager to produce more maize and capable of doing so, with a little help.

Part of that help is coming from the well-trained, enthusiastic scientists of Zaire’s national maize program. But how many farmers the innovations of the maize program reach will depend largely on what national priority is given to finding and training extension workers and to making farm inputs more readily available coupled with efficient marketing systems and outlets.

Origins of PNM
In 1976 Muleba Nyanguila became director of Zaire’s Programme National Mais (PNM). He is 32 years old and has recently completed a master’s degree from Kansas State University in USA. His appointment is evidence of the rapid progress that has been made in the few years since Zaire committed itself to building a national maize program. Zaire asked CIMMYT to help develop a strong program of maize research and training which would ultimately be staffed exclusively by Zairians. A secondary goal was to have the maize research program serve as a model for reorienting research on other crops (see box: ‘Large ripples from a small stone’). Moreover, Zaire said that it would itself provide foreign exchange for expatriate salaries, foreign purchases, and training of its scientists at CIMMYT and at overseas universities.

A 10-year agreement between Zaire and CIMMYT was signed in 1971 and Tom Hart, the CIMMYT team leader, arrived in Zaire in 1972. Since then Zaire has spent about $1 million (U.S. equivalent) a year for the PNM.

PNM now has 25 professional staff members. Twenty of them have been through the CIMMYT maize training course. Four have completed master’s degrees at universities abroad and three are currently working on master’s degrees.

The CIMMYT team in Zaire once consisted of four scientists, but it has been reduced to two as Zairians have returned to the staff from their foreign studies. The current CIMMYT staff members attached to PNM are Hart, an agronomist, and Richard (‘Charlie’) Wedderburn, a breeder/plant protection specialist.

Tom Hart, a U.S. citizen, has been in Zaire since the inception of the maize program. His background includes 6 years in Liberia and other African nations, and teaching at the University of Florida.

Charlie Wedderburn is from the Barbados. He came to Zaire in 1974 after spending a year as a post-doctoral fellow with CIMMYT’s maize program in Mexico. He had previously been an agronomist with the University of the West Indies.

Other scientists who have worked as part of the CIMMYT team in Zaire are James Bullard, USA research farm training officer; Frans de Wolff, Netherlands, maize breeder; and Mahesh Pandey, India, plant protection specialist.
Maize eaters
Zaire, with a population of 26 millions growing at 2.5 percent a year, produces a half million tons of maize annually which is about three-fourths of its needs. The balance is imported.

Most of the maize growing and consumption takes place in the southeastern quadrant of Zaire—Kasai oriental region, Kasai occidental region, and Shaba region. These three regions are as large as Nigeria and contain a third of Zaire’s population.

Here maize is part of nearly every meal. It is commonly eaten as ‘fufu’, a thick paste created by mixing maize flour, and cassava flour, then boiling in water until almost all of the moisture evaporates.

Maize flour is an especially important staple for the non-farm population: city dwellers and miners.

Elsewhere in Zaire, maize can be found, but other crops are more common staples. For the 3 million persons in Kinshasa, for example, cassava and plantains are the basis of most meals. In eastern Zaire, cassava, bananas and rice are predominant.

Of the 150,000 to 200,000 tons of maize that Zaire imports each year, virtually all is purchased by Gecamines, the national mining company. This maize is sold to Gecamines employees at subsidized prices.

For Zaire, the goal of growing enough maize to eliminate imports would not only release foreign exchange for investment in other aspects of national development, it would also raise the incomes of many small farmers.

The maize belt
Southeastern Zaire is a plateau, bordered on the east by Lake Tanganyika and extending into Zambia and Angola on the south and west. From about 1100 meters elevation on the southern border of Zaire, the plateau slopes down toward the north and the great equatorial rain forest — the fabled heart of Africa. The copper mines, which provide 70 percent of Zaire’s export earnings, lie in the plateau.

The plateau is a broad plain, or savanna, broken by clumps of trees and, in places, studded with giant
termite hills. Uncultivated land is often blanketed with a dense, waist-high growth of grasses, like *Imperata cylindrica*.

The Shaba region has the best and the worst soils of southeastern Zaire. Black and yellow soils are usually highly fertile and can yield over 8000 kg/ha with PNM's open-pollinated maize varieties. Substantial areas of red soils in southern Shaba, however, have a high metal content and low pH which make phosphorus virtually unavailable to plants. These soils are relatively infertile.

The infertile red soils were once thought to be typical of the southern Shaba region and that may account for the failure to attempt the type of agricultural development schemes which were instituted in northern Shaba and the two Kasai's. As a result many farmers in southern Shaba who cultivate highly productive soils have never been exposed to any aspect of improved agriculture.

At Lubumbashi in southern Shaba, maize is planted in November and harvested in May. About 1400 mm of rain falls during the growing season. The dry season extends from May through October and light frosts occur frequently from May to August.

To the north, annual weather variations become less pronounced. At Gandajika in Kasai Oriental, freezing weather never occurs. In the coldest month, June, the average minimum is 15 degrees centigrade. The maize-growing season is September to January, but the 1400 mm of annual rainfall are spread out enough to encourage some farmers to attempt a second maize crop in January. A brief dry season occurs June through August.

Zaire's maize farmers
Broader speaking, the maize farmers of southeastern Zaire can be divided into four types: 1) the slash and burn farmers of Kasai occidental and northeast Shaba, 2) the *paysannat* farmers of Kasai oriental, 3) the "advanced" farmers of north-central Shaba, and 4) the poor farmers of southern Shaba.

In Kasai occidental, the humid savanna merges into the tropical rain forest. To open a new field, farmers fell trees more than 30 meters tall and burn them. The soil is roughly cultivated and the maize grows here and there among the stumps and charred logs. Farmers have about 0.5 hectare of maize which yields about 500 kg/ha. When the soil is exhausted, farmers clear a new field.

The pattern is similar in northeast Shaba. The chief difference is that northeast Shaba is less humid so the trees are not as tall.

The *paysannat* scheme in Kasai oriental is a sort of systematized shifting cultivation, based on cotton. The system imposes the position of fields and the crop planted. By having each farmer's cotton field next to his neighbors', government tractors can plow and cultivate in one long strip, and aerial spraying is possible, but is not practiced. The cotton agency also provides fertilizer. At harvest it buys the cotton and deducts the costs of the services and materials it has provided. In the next year, cotton is planted in new fields and maize is planted in the former cotton fields. Farmers interplant cassava with maize. The cassava continues to grow while the maize is harvested and a second-season maize crop is planted. After the second maize crop, the cassava may remain in the soil for 2 years more or peanuts may be planted. After that, the field reverts to bush for 9 years.

The average *paysannat* farmer grows a half hectare of cotton and a half hectare of maize. The maize yields about 750 kg/ha in the main crop. The second-season crop yields only 50 to 200 kg/ha because of erratic rainfall and increased disease incidence, and competition from cassava.

In the Kaniama area of north-central Shaba many farmers grow tobacco and maize. The national tobacco agency plows the tobacco fields for the farmers and provides fertilizer. Maize is a second-season crop following tobacco and it benefits from...
A village chief, the local maize production specialist, and Tom Hart, CIMMYT team leader, laugh at an anecdote being told by Bosa Ngutani Ndopetelo, chief of extension in Shaba.

the high rates of fertilizer used on the tobacco. The farmers have 5 to 30 hectares of maize and get yields of 2000 to 3000 kg/ha.

Some farmers in the Kaniama area who do not grow tobacco achieve even higher maize yields than tobacco growers. These farmers have 0.5 to 3 hectares of maize. Because they don't plant tobacco, they can plant maize earlier in the season. That headstart reduces disease damage and with fertile soils yields go over 4000 kg/ha.

Further south in Shaba region, in the mining area, maize farmers have never received advice about cropping nor have they seen improved agriculture. Their maize plantings range from 0.3 to 0.5 hectare. They plant late, use a low plant density and do not apply fertilizer. Yields range from 100 to 1500 kg/ha.

Up by the bootstraps

When the Zaire maize program began in 1972, the nation had only a handful of trained agriculturalists and few of them worked with maize. Currently the maize program has 25 professional staff members. Four of these scientists hold master's degrees in agricultural disciplines. And as Muleba Nyanguila says, 'Now much of the PNM staff is at the international level'.

Building the staff of the maize program has been just as much a process of testing and selection as plant breeding. To recruit professional-level staff members, the maize program looks at agriculture graduates of 3-year and 5-year university curricula and graduates of 6-year technical high schools.

For one crop season these new graduates work alongside the regular staff—planting, weeding, fertilizing, measuring, detasseling, pollinating, harvesting, shelling, treating seed, and so forth. 'This is a tough period for them', says Tom Hart, 'because they come out of a highly theoretical training'. After 10 months in sun, rain, and muddy fields, the young graduates who have the stamina for field research stand out.

The best are sent to Mexico to take the 6-month in-service training course at CIMMYT. On their return to Zaire they work as junior staff members. They are given more responsibility. They help train new candidates, they supervise certain trials, work with farmer-cooperators, and often do a tour as the manager of a research station. They have the opportunity to go to conferences elsewhere in Africa. 'We move staff to other countries and around within Zaire so that they can see how other people face and solve problems' says Muleba Nyanguila.

After a year or so, outstanding university graduates are sent for advanced degrees abroad. The other junior staff members become research technicians, extension staff, and administrative assistants.

When the three staff members currently abroad return to Zaire the maize program will have scientists with graduate training in breeding, physiology, soil chemistry, agronomy, and pathology. 'We still need an entomologist, a farm manager, and an agricultural economist', observes Muleba Nyanguila.

The education of the scientists has been at Kansas State University, Iowa State University, Cornell University, and Texas A&M University. 'Every one of our graduate students has done well', observes Tom Hart. Muleba himself has completed his coursework for a Ph.D. degree from Kansas State University and is doing his dissertation research in Zaire.

At the non-professional level, PNM trains graduates (and some non-graduates) of non-technical, 4-year high schools to become maize production specialists. Muleba takes pride in the success of the PNM training course for maize production specialists: 'We are able to take graduates with no experience in agriculture and train them for 6 months and have them come out well'.

Most of the maize production specialists have gone on the staff of the Shaba regional director of agriculture as village-level farm advisors. Many act as supervisors of farmers participating in the PNM credit extension scheme. A few of the maize
production specialists, however, remain in PNM as research assistants.

By 1977, 27 university graduates had been trained, and 23 were still working in PNM. Two graduates of technical high schools had been trained at the professional level, and 70 persons had been trained as maize production specialists.

**Tougher varieties**

PNM's maize breeders are striving for higher yielding varieties that meet the preferences of farmers, that fit the various growing seasons, and that have genetic resistance to the organisms that attack maize.

The most destructive enemies of maize are two diseases, maize streak virus and downy mildew. Maize streak virus is caused by a virus-like agent and is unknown outside Africa. Downy mildew is caused by a fungus. Streak is more severe in the warmer, lower areas of Zaire than in the more temperate, higher elevation areas. Downy mildew has not been found in the high plateau; however it seems to be moving closer every year.

Generally, areas that suffer severe outbreaks of downy mildew do not get heavy attacks of streak, and vice versa. The diseases can usually be avoided by prompt planting when the rainy season begins; the pathetically low yields of late planted maize and second-season maize are primarily caused by severe downy mildew or streak virus infection.

Two foliar diseases, caused by *Helminthosporium maydis* and *H. turcicum*, are unimportant on varieties that contain African maize germ plasm, but high incidences are found in many varieties introduced from other continents.

The worst insect pests are cutworms, which attack late planted maize in Shaba region, and rootworms. Stored maize is often heavily damaged by insects.

Before 1972 the most common maize in Zaire were GPS4, GPS5, Hybride Double, and Hickory King. The first three were developed by INEAC, now INERA (Institut National pour L'Etude et La Recherche Agronomiques). Hickory King is an old variety from USA. These maize varieties have a low inherent yield potential and Hybride Double performs particularly poorly because farmers save seed from their own fields and plant it for several seasons despite yield depression.

The advantage of the locally developed varieties is that they have some tolerance to downy mildew. When planted late and attacked by downy mildew they succeed in yielding perhaps 500 kg/ha, while susceptible varieties yield nothing.

The first variety PNM produced was Shaba Safi, which is an open-pollinated variety created by crossing a hybrid from Kenya with a hybrid from Rhodesia. Although Shaba Safi is high yielding, it is tall and tends to lodge (topple over). PNM crossed Shaba Safi with several short populations from CIMMYT and the best performing cross was released as PNM 1 in 1974. PNM 1 allowed the maize program to offer Shaba farmers a variety that has three to four times the yield potential of older varieties. Without this variety, demonstrations of improved farming methods would not have been nearly as dramatic and convincing.

PNM continues to use Shaba Safi in crosses with introduced maize to produce varieties for Shaba region. ‘Anything with Shaba Safi we consider for southern Shaba. In the north other materials are

Two farmers watch Bosa demonstrate how thoroughly their fields should be weeded.
superior’, says Charlie Wedderburn. When crossed with germ plasm from CIMMYT, for example, Shaba Safi gives the progeny resistance to *H. turcicum* and lengthens their growing season. In southern Shaba a 180-day growing season is needed to bring the harvest out of the rainy season. The CIMMYT germplasm in these crosses provide shorter height, and better resistance to ear rots.

At the same time as PNM 1 was being produced, maize scientists looked for a suitable material for the warmer areas of northern Shaba and the Kasai’s. In these areas, varieties with long growing seasons are not needed and, as Charlie Wedderburn puts it, ‘nothing does better than straight CIMMYT materials—if they are planted within 1 month of the first rains’.

The CIMMYT population Tuxpëño 1 performed particularly well. Scientists in Zaire selected 10 families, which all yielded over 9000 kg/ha, intercrossed them, and released the variety as Salongo in 1974.

Both PNM 1 and Salongo have potentially higher yields than previously available varieties, but they are vulnerable to maize streak and downy mildew in late plantings. To permit farmers more than a 1-month safe planting season, PNM scientists have to build up resistance to streak and downy mildew in future varieties. New varieties will come from four populations—Tuxpëño x Eto and Salongo for the lowlands, and (Tuxpëño x Eto) x Shaba Safi and PNM 1 for the temperate highlands.

These populations will be improved by selecting for high yielding and shorter families. Preliminary trials were conducted to determine date of planting for maximum disease incidence. To strengthen the disease resistance in the two lowland populations, the representative bulk is planted at an appropriate date later in the season when more than 90 percent of the plants show susceptibility to streak or downy mildew. In late plantings, it is common to have 90 to 98 percent of the plants show susceptibility to streak or downy mildew. PNM researchers self-pollinate the resistant plants and then sow the seed in the ‘second-season’ when disease incidence is even more severe. Progeny from the surviving plants are used, in the following season, to cross with the best yielding families of the same population.

The same system is used for improving the disease resistance of the temperate populations except that testing is only for maize streak and also that no ‘second-season’ exists in highland areas.

To maintain pressure against disease susceptibility and tallness, breeders eliminate undesirable plants in all crossing plots and in seed multiplication plots.

PNM also participates in international downy mildew and streak screening trials. The downy mildew resistance trial distributed by the Inter-Asian Regional Maize Program has so far had limited value for Zaire. While a few entries in this trial have shown good resistance, they all have yellow kernels. Yellow maize has no direct value since farmers in Zaire grow white maize exclusively.

Zaire and Tanzania test CIMMYT populations for sources of resistance to maize streak. In 1976, the first year of the CIMMYT streak trial in Zaire, 4800 families were planted late in the season in north-central Shaba. Sixty percent of the families were susceptible. The resistant plants were self-pollinated and the resulting seed was divided into three sets. One set will be planted in Zaire for rescreening. One set was sent to Tanzania for screening against streak there. And the third set went back to CIMMYT for regeneration of the population. PNM also cooperates with IITA’s maize streak studies.
National trials
PNM conducts a combined variety and fertilizer trial each year in maize-growing regions of Zaire. The trial allows experimental varieties and newly released varieties to be compared with older varieties under different conditions. Three fertilizer levels are used. They approximate farmers’ practices (zero fertilizer), PNM’s recommendations (60 kg/ha of nitrogen and 60 kg/ha of phosphate), and double the recommended rates. The 1975/76 trials give an indication of the potential of practices and varieties developed by PNM to boost yields.

The PNM varieties tested were PNM 1, Salongo (Tuxpeño x Eto) x Shaba Safi, Tuxpeño x (Mix 1 x Colima Grupo 1) x Eto; (La Posta x Eto) x Shaba Safi; and Tuxpeño x Eto; GPS5 and Hybride Double were the check varieties. Fourteen trials were conducted, and the results can be grouped geographically.

Heaping soil to make large beds is a slow, exhausting work.

In the Kasai oriental and North Shaba areas, with recommended fertilizer rates, the two highest yielding PNM varieties averaged 4300 kg/ha or 14 percent more than the best yielding check variety. With no fertilizer, the best two PNM varieties averaged 2300 kg/ha, 20 percent more than the best check.

In central Shaba, around Kasese and Kaniama, soils are highly fertile and fertilizer made little difference in yield. With the recommended fertilizer rate, the two best PNM varieties averaged 8100 kg/ha, 31 percent more than the best check. Without fertilizer the PNM varieties yielded 7900 kg/ha, 37 percent more than the best check.

In south Shaba, the two best PNM varieties averaged 6300 kg/ha at recommended fertilizer rates, 35 percent more than the best check. Without fertilizer, the PNM varieties yielded 4900 kg/ha, 34 percent more than the best check variety.

Averaged over all sites, (Tuxpeño x Eto) x Shaba Safi performed best. It yielded 5000 kg/ha without fertilizer, 6300 kg/ha with the recommended fertilizer rate, and 7000 kg/ha with double the recommended rate.

Rotations and intercropping with legumes
While applying fertilizer is a valuable farming practice, it is not the only way to take advantage of the higher yield potential of the new varieties. PNM is examining rotations and intercropping with legumes as a means to improve soil fertility without nitrogen fertilizer. Tom Hart believes that rotations with a legume would be attractive for many farmers in Zaire, who live where land pressure still is not great. To operate a rotation system, a farmer would have to open an additional plot of land equal in size to his maize planting. Maize would be planted on half the land and the legume on the other half. In the following year maize would be planted in the former legume field and would benefit from the nitrogen fixed by the legume. The former maize field would be then planted to the legume, and so on.

PNM is comparing two legumes, crotalaria and soybeans, in rotation with maize. So far crotalaria has shown a superior ability to fix nitrogen in trials in southern Shaba region. Maize following crotalaria has yielded 9000 kg/ha. That equals the yield of continuous maize with 180 kg/ha of nitrogen and 120 kg/ha of phosphate (three times the recommended fertilizer rate), and is more than double the yield of unfertilized continuous maize.

Soybeans have not been as successful. Maize following soybeans has yielded only 6700 kg/ha. But much remains to be learned. In these trials, soybeans were planted in rows while crotalaria was broadcast seeded. Possibly the higher density
A grain mill in Chef Katanga village grinds maize for the village families.

of crotalaria plants accounted for its greater nitrogen fixation. Also another variety of soybeans might perform differently. Adjustments in crop management and variety might make soybeans competitive with crotalaria in nitrogen fixation. If so, soybeans would be advantageous for farmers because they provide food while crotalaria is exclusively a green manure crop.

On the other hand crotalaria competes strongly with weeds and, over time, it might lower the concentration of weed seeds in the soil.

Intercropping, of sorts, is done by many farmers. Traditional intercropping tends to be a low intensity, low investment activity. Maize and one or more other crops may be interplanted, but the plants are far apart and often poorly managed. Yields are low.

PNM is investigating whether legume intercrops can be used to fix nitrogen and raise maize yields, while at the same time providing an extra food crop.

The trials began with cowpeas as the intercrop because cowpeas are a popular food in parts of Zaire. For seed, six batches of local cowpeas were bought in the Candajika market and mixed, but when planted, 'they were riddled with mosaic', a virus disease. The effect of these weakened legume plants showed up the next season. The maize yielded only 3700 kg/ha, considerably less than heavily fertilized maize, but more than unfertilized maize grown after maize.

PNM also tested some imported cowpea varieties. Although these varieties were resistant to mosaic and fixed nitrogen well, insects attacked the flowers and pods so no seeds set.

Because of the difficulty in finding suitable cowpea varieties, PNM has shifted its intercropping work to soybeans.

The chief agronomic question in intercropping trials is how to keep one crop from smothering the other. Scientists are testing various planting dates to find the combination that permits optimum
yields of both crops.

Both rotations and intercrops appear to offer much to Zaire's maize farmers. Certain agronomic questions remain, but methodical research should be able to provide solutions. Farmers will have to modify their farming techniques, as is true of any procedure for raising productivity. Rotations and intercrops also have the advantage that they could give the farmers some safeguard against the uncertainty of international nitrogen fertilizer prices and deliveries.

Legume rotations and intercrops are not totally free of problems, however. For one thing, legume seeds are notably difficult to store from one season to the next. A large-scale attempt to introduce soybean intercrops, for example, will founder if the first adopting farmers find that soybean seed germinates poorly. Another problem is that even with legumes, many farmers will need fertilizer for high yields. Legumes will not do well in low phosphorus soils such as are common in maize-
growing areas of the Kasai's or red soils of South Shaba.

Thus in the long run, there can be no substitute for sustained, wide-ranging research to identify the reefs and shoals of technological change and to plot courses that will avoid them.

**Improving traditional practices**

Most farmers in Zaire plant maize in large beds. Farmers build the beds by laboriously hoeing soil into ridges about a half a meter high and 1 meter apart. They plant 2 to 4 plants in hills which are about 50 centimeters from each other along the bed. During the season farmers throw weeds into the furrow between beds and after harvest they add maize stalks and leaves to the residue. For the next season's planting they break up the old beds and construct new ones where the furrow and residues had been.

This system has several possible benefits. First, it provides good drainage if maize is grown in low-lying wet soil. Second, compared with growing maize without beds, the maize roots can reach more topsoil and therefore have better access to mineralized organic matter. Third, the incorporation of the weed and crop residues provide some nutrients to the next season’s crop.

But these benefits are not as great as they might appear. Land is relatively abundant in Zaire, so there is little reason to grow maize in poorly drained soil. In addition, the decaying crop residues actually provide little nitrogen to the maize crop. The residues contain a high proportion of carbon and a low proportion of nitrogen. Because of the wide C:N ratio microorganisms decompose the organic matter slowly and keep the nitrogen in a form unusable by plants until decomposition ends. By that time the maize is flowering or near or past harvest.

Most important, however, is the slow, back-breaking task of piling soil into high beds. The time and energy needed to make beds keeps farmers from preparing and planting their fields promptly after the rainy season begins and it limits the amount of land they can cultivate.

PNM is encouraging farmers to shift to “flat”

Chiles are a fundamental food crop.

Palm oil plays a large part in agricultural income.
culture (planting in hills without beds) and to use fertilizer. Nevertheless PNM recognizes that many farmers will be slow to change, so it is attempting to improve the traditional technique by introducing a legume intercrop in the furrows. The principle is that the legumes would fix nitrogen in the soil thus improving the C:N ratio when the residues are decaying. As a result, nitrogen would be immobilized more briefly and it would be more readily available for the subsequent maize crop.

The results of the trials so far have been mixed. In the first year, crotalaria was the legume intercrop. The crotalaria grew thick and tall and overwhelmed the maize plants. Since the nitrogen fixed by a legume is mostly not available in the season in which it grows, the effect of nitrogen fixation by crotalaria could not be determined until the following season. Maize planted in crotalaria residues yielded nearly twice as much as maize planted in ordinary maize fodder. Unfortunately the cowpeas grown in the second season were attacked by virus diseases so they did not grow well. The consequences showed up in the next year.

Once again cowpeas were grown. In one trial, maize grown in cowpea fodder residues yielded 60 percent more than maize planted in maize fodder residues. But in a trial on another soil type, maize following cowpea residues yielded slightly less than maize following maize residues.

Because the poor growth of cowpeas in South Shaba affects their ability to fix nitrogen, PNM is continuing the trials with soybeans as the intercrop, since soybeans grow well in South Shaba.

Farmers try the new practices
In the few years since it began, PNM has produced impressive experimental results. But can new ways of farming be transferred to small farmers? Aren't poor farmers who cultivate only a hectare or two uninterested in new ideas or better livelihoods? Some people think so.

Since the 1973/74 season, PNM has operated a pilot project to show that it has developed practices which small farmers can use profitably.

The basic recommendations of PNM are to use good seed of a good variety, to plant soon after the rains have started, to seed densely, to apply fertilizer, and to keep the fields weed-free.

To get the project going, PNM provided participants several things that are scarce in Zaire's maize economy: credit, a source of seed and fertilizer, and technical advice. For this reason, the project is called a supervised credit scheme.

Here's how the scheme works. Before planting, PNM identifies the farmers who want to participate. The number of villages and participants is limited by the scarcity of fertilizer and the gasoline needed to distribute it. Well before planting PNM delivers fertilizer and seed. The fields to be planted are measured by the village maize production specialist to be sure that the fertilizer dose is correct. The farmers prepare the land, apply fertilizer, and plant the maize. The maize production specialist observes the planting and may offer advice. Between planting and sidedressing (application of a second dose of fertilizer), the PNM staff visits the fields to see if farmers are weeding. At the time of sidedressing, the farmer is encouraged to weed again. At harvest time, the PNM staff returns and cuts small samples to measure yields. After harvest

COOPERATING WITH OTHER AGRICULTURISTS

The activities of the PNM's researchers affect more than just Zaire's maize farmers. Through PNM's participation in meetings elsewhere in Africa, other maize farmers potentially benefit from PNM's work. Scientists from PNM have explained their research at regional meetings of maize workers in Kenya and Ethiopia. They have discussed the supervised credit scheme with maize researchers from Tanzania. PNM has shared maize germ plasm with scientists in such countries as Malawi, Zambia, Nigeria, Cameroon, and Ghana.

PNM also helps outside agencies by planting and taking data on trials sent to them. PNM has grown such maize trials as the East African Variety Trials (from Kenya), the West African Variety Trials (from IITA), and the Inter-Asian Corn Program downy mildew trials. In addition it has grown cowpea and soybean trials from IITA.

Since PNM staff members are knowledgeable and widely traveled in Zaire their opinions are frequently sought by visiting study groups interested in subjects like grain marketing, seed production and distribution, fertilizer, soil analysis, and legumes.

For the North Shaba project, an integrated rural development scheme financed by the government of Zaire and the U.S. Agency for International Development, PNM developed a set of maize farming practices to be introduced there. PNM supplied staff members for the project. One of them is the director of all agricultural activities in this project.
the farmer is expected to pay back the value of the seed and fertilizer he has used in cash or in grain (the cost of seed and fertilizer has been subsidized about 40 percent below the market price).

In 1973/74, the first year of the scheme, the total recommended fertilizer application was 129-115-38. Because PNM had access to very little fertilizer, only 15 farmers could participate. The farmers were located in eight villages and their average maize planting was one-quarter hectare. Yields averaged 5100 kg/ha and 91 percent of the credit extended was paid back.

The next year the scheme had 146 participants in 10 villages. The recommended fertilizer level was reduced to 50-60-40. This rate better approximates the economic optimum for Zaire's small farmers, the average maize planting was 0.6 hectare and the average yield 3200 kg/ha. Sixty-nine percent of the credit was repaid.

In 1976/77, 168 farmers in eight villages participated. A fertilizer rate of 64-45-30 was recommended. The average maize planting was 0.4 hectare. Yield averaged 4700 kg/ha. Sixty-nine percent of the credit was repaid.

Grain mill production in Chef Katanga village

Unfinished business

A plan written in 1975 by economists and maize scientists from PNM and CIMMYT points up the difficulties Zaire must begin to overcome to raise Crotalaria, a legume, fixes large amounts of nitrogen in the soil. PNM is testing rotations of crotalaria and maize.
SURVEYING MAIZE FARMERS

Opinions and impressions about how Zaire’s farmers produce and use maize are easily found. But to shape PNM’s research priorities and national plans for raising maize output, more trustworthy information was needed.

PNM and CIMMYT located a young Zairois, Mbumi Mwamufiya, who was enrolled in a Ph.D. program in agricultural economics at Oregon State University (USA). Don Winkelmann, CIMMYT economist, proposed that Mwamufiya survey maize farmers in Zaire and write his dissertation based on the findings. Mwamufiya agreed and Winkelmann helped plan the survey and found money to support it through the U.S. Agency for International Development. PNM helped find survey takers and provided living quarters and a car.

The survey was conducted in 1974/75 in the important maize-growing area made up by Kasai Oriental region and north central Shaba region.

Some of the highlights of Mwamufiya’s findings:

- In the area surveyed, maize is less important than cassava whether measured by area planted or quantity harvested. Maize interplanted with other crops occupies about the same area as maize planted alone.
- Most farmers use only a hoe for cultivation. Few use tractor services. None use draft animals.
- Most farmers use traditional maize varieties. Farmers usually save seed from their previous harvest.
- Farmers rarely use other than family labor to produce crops. Men tend to clear the land while women participate in sowing and weeding. Women do most of the harvesting and marketing.
- About two-thirds of the farmers surveyed sold some of their maize. Most sell less than 30 percent of their production. High transportation costs because of poor roads and lack of vehicles and gasoline discourage farmers from marketing maize.
- About half of all maize marketings occur in the first 2 months after harvest. As a result, seasonal price swings are enormous. Mwamufiya suggests that better storage facilities might allow farmers to hold maize until prices are better and thus act as an incentive to greater production.
its maize output substantially or the severe cost of failing to do so. The plan set out steps to dramatically reduce, even eliminate, maize imports within 5 years.

The plan estimated that Zaire was importing 150,000 tons of maize in 1974 and that by 1976 it would be importing 174,000 tons, which at 1974 prices would cost over US $30 million in foreign exchange. The plan suggested that improved technology could raise yields by 2000 kg/ha. Thus if improved technology could be brought to 100,000 hectares by 1976 the maize deficit would be more than eliminated. As part of the improved technology, Zaire would have to increase its imports of fertilizer. By 1976 the plan called for 20,000 tons of imports annually. But the cost of that amount of fertilizer would be about one-fourth the cost of the maize that would have had to be imported. (An alternative target, cutting maize imports by three-fourths by 1979, would require 75,000 hectares under new technology and 15,000 tons of fertilizer imports. Cutting imports in half would require 55,000 hectares under improved technology and 11,000 tons of fertilizer.

A program to eliminate or sharply reduce maize imports has not as far been launched. Nevertheless the PNM-CIMMYT plan identified the key elements needed whenever a broad-scale production campaign is begun in Zaire.

The most critical barriers to a successful production campaign in Zaire are the shortages of trained farm technicians and fertilizer. The plan recommended that to introduce improved technology on 100,000 hectares in 5 years, 20 to 30 new maize production specialists should be trained each year. In addition, four to six college graduates should be trained annually for supervisory positions.

Purchases and delivery of fertilizer would have to be carefully managed, the plan said. The fertilizer would have to be bought abroad many months ahead of the planting season to allow time for shipping and the transhipments needed to bring fertilizer to the interior of Zaire. Moreover, there should be a commitment to continuing to supply fertilizer. Making fertilizer available in one year and not in the next undermines farmers’ trust in government schemes.

The plan specifically recommended that urea and diammonium phosphate be imported. These are highly concentrated fertilizers so they would be more economical to ship and store than other sources. In addition, two 55-kilo sacks of both fertilizers would provide 67 kilograms of nitrogen and 46 kilograms of phosphate which is roughly PNM’s recommendation for a hectare of land.

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**THE LEVERAGE OF INCREASING SMALL FARMER OUTPUT**

Bringing improved technology to small farmers will, potentially, have a powerful impact on the amount of farm products sold. For example, a typical farmer might grow a half hectare of maize which produces 375 kilograms (750 kg/ha). From his harvest, he might set aside 285 kilograms to eat, and sell 90 kilograms.

If technology raises the farmer’s yield by 2000 kg/ha, his farm output would be 1375 kilograms, With larger output the farmer might increase his consumption to 500 kilograms, leaving 875 kilograms to be sold. In other words, raising the farmer’s yield four-fold might raise the amount of grain being sold ten-fold.

**LARGE RIPPLES FROM A SMALL STONE**

The Programme National Mais is an instrument for attacking some of Zaire’s fundamental problems. First, its work offers hope for putting the brakes on maize imports. The swelling volume of imported maize is a pernicious drain on Zaire’s scarce foreign exchange. Second, its work offers a way of raising incomes in rural areas and decreasing the grinding poverty that propels people into urban areas where they join the masses of underemployed. Third, it offers an example of fast-payoff research upon which Zaire can model programs for other crops and livestock. It also serves as an outstanding example for Zaire’s National Research Organization (INERA).

To start the campaign, the study identified priority areas. The Kaniama-Gandijika area of Kasai oriental and north-central Shaba region would be the best initial focus, the plan said.

Farmers in that area, especially participants in cotton and tobacco schemes, would be highly receptive to better maize-growing methods. Later the campaign would expand to other areas.

Marketing and storage facilities need to be built or improved. Buying offices should be established in rural areas to offer a conduit for maize from the fields to cities. The study suggested that the buying offices not compete with small traders. Rather the offices should offer floor prices and buy grain when increased production threatens to swamp the normal marketing channels in the rural areas. Otherwise, increased production might
The national maize program has developed varieties and found practices that can double and triple yields.

overwhelm local traders, especially in the first years of the campaign, and force prices so low that farmers are discouraged from growing maize (See box: 'The leverage of increasing small farmer output').

Buying offices would need scales, cribs to store maize, and shellers to process it. The major rail heads at Luputa or Mwene Ditu would need large storage facilities to hold maize pending shipment to population centers. In addition, Luputa or Mwene Ditu would need storage buildings for incoming shipments of fertilizer.

High density intercrops of maize and soybeans being tested by PNM offer a way for farmers to raise maize yields and improve their diets.

At the experiment stations, storage facilities would be needed for the 100 to 200 tons of seed to be distributed each year.

The steps outlined in 'Zaire's strategy for maize research and production' will not be easily accomplished. PNM, itself, is capable only of providing foundation seed, recommendations, advice, and training. The manpower, money, and motivation to spread PNM's research widely, thereby saving the foreign exchange spent on maize imports and raising rural incomes, will have to come from government leaders. — Steven A. Breth
Members of the PNM staff check crop prospects with one of the farmers participating in the supervised credit scheme.

Charlie Wedderburn, CIMMYT maize breeder, and Kanku Mukanya wa Shambuyi of the PNM staff.
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