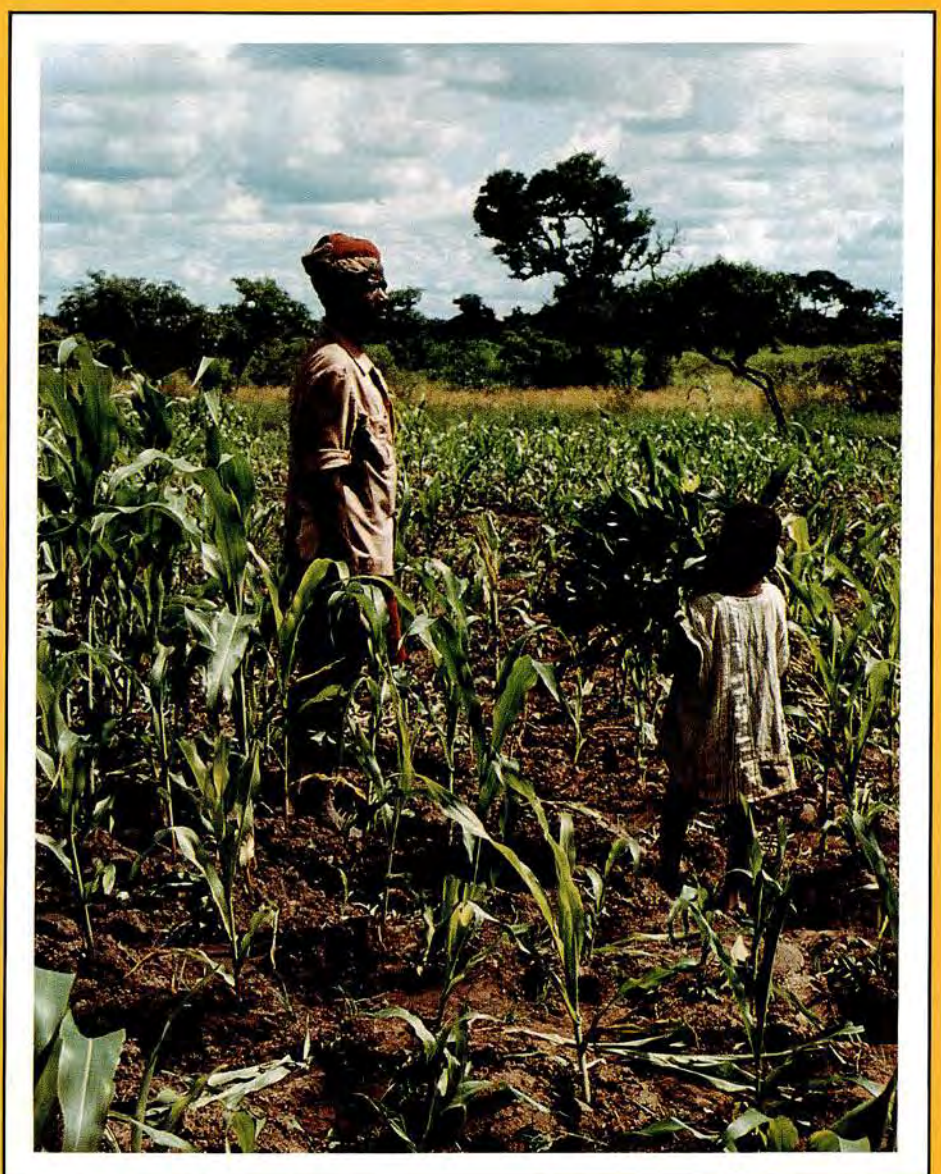
Proceedings

Workshop 1989

Feeding The Future:
Agricultural Development Strategies
for Africa
CASIN/SAA/GLOBAL 2000



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Workshop 1989

Feeding The Future: Agricultural Development Strategies for Africa

CASIN/Sasakawa Africa Association/Global 2000

August 1-3, 1989
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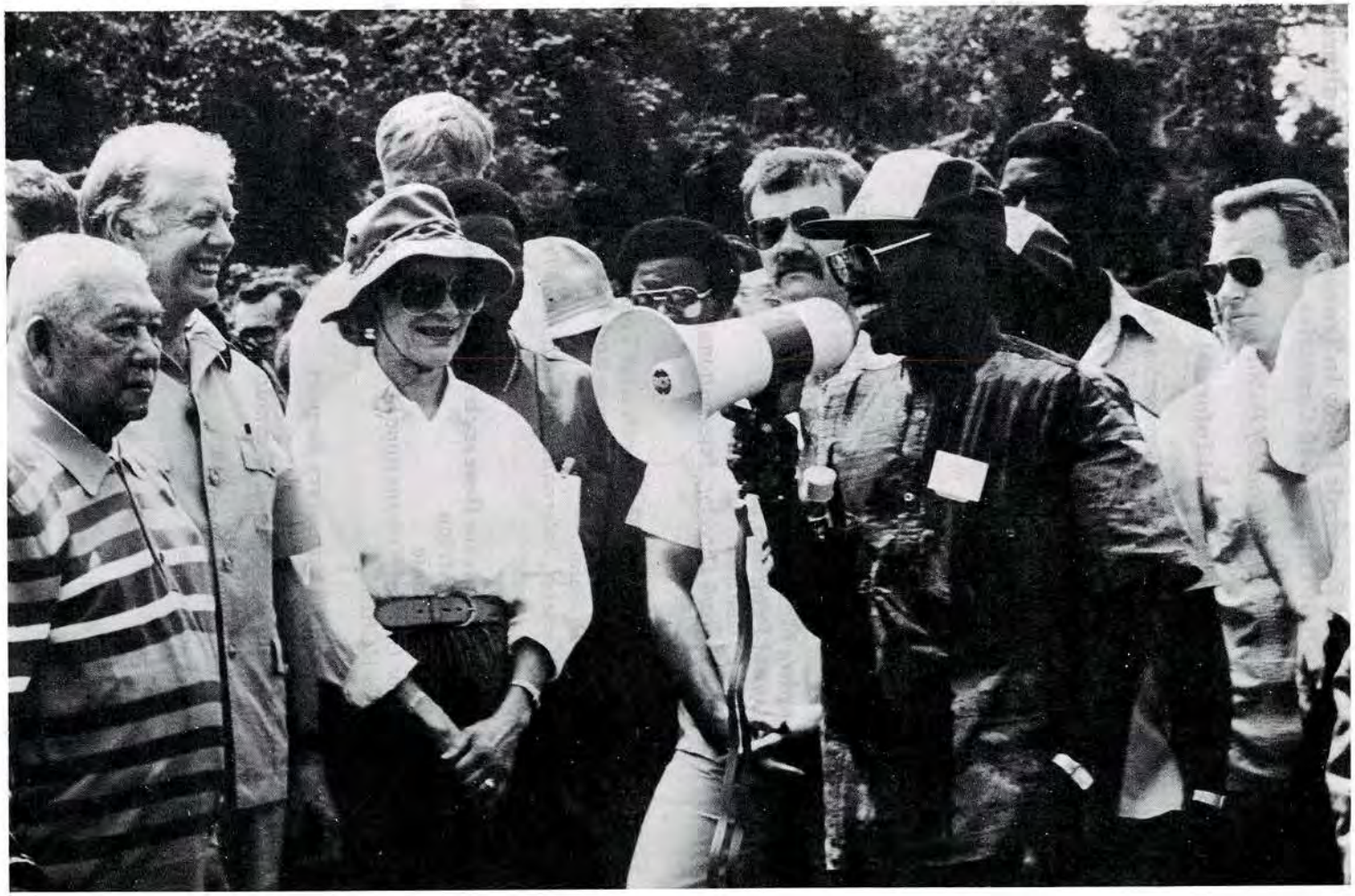
Contents



Foreword

*Jean F. Freymond**

In July 1985, some thirty specialists of many disciplines and representatives of public life gathered in Geneva in reaction to the African food emergency. They reviewed food strategies for Africa and examined a range of policy options leading to sustained self-reliance. Pilot-projects were identified, some of which, one year later, began to be implemented. This started an experiment which, building up on the research work of institutions like CIMMYT, ICRISAT and IITA, intended to demonstrate that, in many parts of Africa, through the use by farmers of appropriate agricultural technological packages, hunger and malnutrition might be reduced.

Workshop 1989 was the fourth in a series of similar gatherings. Participants reviewed the achievements of projects in Ghana, the Sudan, Zambia and Tanzania as well as to discuss numbers of critical dimensions essential for the long term sustainability of the program: inputs supply of seeds and fertilizers, links between research, extension and production, output marketing systems and credit policies.

The Workshop provided an opportunity to critically assess agricultural development strategies for small-farmers for the years to come. Workshop 1989 was also conceived to allow a range of specialists and representatives of national and international organizations to get better acquainted with the approach followed in the Sasakawa-Global 2000 crop technology transfer programs and to provide suggestions regarding policies to be next implemented.

During Workshop 1989, many thoughts, insights and proposals were circulated in the form of papers which launched in-depth exchanges of views. Those papers were considered worthy of a wider audience, one interested in ideas and innovative perspectives which should enrich the debate on agricultural development strategies for Africa. The proceedings of Workshop 1989, edited by Chris Dowswell, should not be seen merely as an input into an intellectual dialogue. Rather they should serve, and such is their main objective, to further contribute to the alleviation of hunger and malnutrition in Africa.

I do not want to end this foreword without expressing my gratitude to the team who worked so hard and with so much dedication to make a success of this conference: Mrs. Gertrude Monnet, Elizabeth Eson-Benjamin, Nana Ya Omane, Veronique Hayoz; Messrs. Steve Lawrence and Pablo Espresate. My heartfelt thanks also to all the officials of the goverment of Ghana who have been involved in this event.

* Director, Centre for Applied Studies in International Negotiations, (CASIN) Geneva, Switzerland. Geneva, July 1990.

Welcoming Speech

Justice D.F. Annan
PNDC Member, Government of Ghana

Mr. Chairman, Your Excellencies, Colleague PNDC Members & Secretaries, Members of the Diplomatic Corps, Distinguished Delegates, Ladies and Gentlemen. It is my pleasure to welcome you all to the opening session of this very significant Workshop.

In particular, I must say how pleasant it is to have with us once again our three special guests whose dedication in commiting to the Global 2000 project their time, energy and resources is always an outstanding example of their understanding of the real needs of the developing and disadvantaged countries.

I am referring, of course, to Mr. Jimmy Carter, former President of the United States, Mr. Ryoichi Sasakawa, and Dr. Norman Borlaug.

It is also gratifying to see the wide array of international experts, from sister African countries and beyond, who are here to share in the deliberations and exchange of ideas at this Workshop. On behalf of the people and Government of Ghana, and on my own behalf, I welcome all of you and wish you a pleasant and useful stay with us.

Mr. Chairman, Distinguished Ladies and Gentlemen, the theme for this Workshop is "Feeding the Future". Theoretically, it would be feasible to feed the hungry, poor and deprived people of this world simply by a redistribution of the surplus food production of certain technically advanced nations, who have "grain mountains", "meat mountains" and "milk lakes" to dispose of. But we of the developing countries would wish that this kind of aid would become relevant only in emergency situations such as unforeseen disasters.

What we want is to be able to feed ourselves, to achieve the dignity of self sufficiency in basic food needs, and to escape from the type of aid which engenders further dependency and undermines, rather than encourages, our own agricultural efforts.

We in Ghana must express our deep appreciation to those who conceived, supported and continue to implement the Global 2000 program, because it is precisely the kind of assistance which is needed. Unlike some kinds of development aid, it does not disrupt existing agricultural and social systems, but interlocks smoothly with our own policies and practices. It focuses on the hardworking small-scale farmer, who is the backbone of our economy, and makes him more productive and therefore able to improve his standard of living.

The proof of its success can be seen in the way that, each year since the beginning of the project, more farmers have flocked to join after seeing the remarkable increases in yields on their neighbors' farms. I am sure that you will be given plenty of statistics during the course of this Workshop. Suffice it to say that the response of our farmers and, I must add, our agricultural extension workers and other agencies involved in the program, is adequate testimony of the success and the correct orientation of the Global 2000 project.

Mr. Chairman, distinguished participants, we have made considerable strides in the most basic problem--that of enabling the ordinary farmer to obtain greatly increased yields by the application of simple, easily understandable technology which involves a minimum of capital input.

This puts us in a position to take another important step, and I am pleased to see that the organizers of this Workshop acknowledge this by the inclusion of agroforestry experts among the invited participants.

Much of the environmental degradation of this country, and of other parts of Africa and the developing world, is due to agricultural practices such as shifting cultivation which are ecologically viable only in relatively sparsely inhabited areas. Our growing population, in a situation where most farmers still practice the traditional but no longer appropriate methods, puts increasing pressure on the few remaining areas of fertile virgin land. Thus we have deforestation, increasing soil erosion, the drying up of water sources, illegal encroachment into forest reserves, and other forms of degradation, all in the search for more productive land.

The only answer to this problem is the development and acceptance by our small scale farmers of permanent, sedentary agriculture.

But this can only become acceptable to them when they are confident of their ability to increase their yields, and to sustain these improved yields.

Global 2000 has tackled one aspect of increased productivity with conspicuous success. We now need to look at ways to integrate this advance with other methods of improving and maintaining soil fertility, with a view to gradually but urgently weaning our small-scale farmers away from bush fallow systems and towards permanent cultivation.

This must involve simple rotation of crops and also various aspects of agroforestry, including methods such as alley cropping.

Mr. Chairman, distinguished guests and participants, Global 2000 began its work in Ghana with a simple brief--to disseminate methods for making a given plot of land yield more.

But its field officers observed that in some parts of the country, a major factor hindering agricultural productivity was the incidence of guinea worm, which incapacitates many farmers for weeks or even months at a time.

Recognizing the problem, Global 2000 lost no time in helping to address this other dimension of low agricultural productivity.

I am therefore very confident that you, Mr. Carter, Mr. Sasakawa, and Dr. Borlaug, and your organization will also recognize our need to encourage our farmers to adopt farming systems which are not only more productive in terms of annual yield per hectare, but which can be permanently sustained so as to reduce environmental degradation.

Ladies and gentlemen, it is gratifying to note that the newly created unified Extension Services Department in the Ministry of Agriculture is performing well, taking advantage of the experiences of Global 2000 and other agencies, in its assignment of imparting to our farmers improved technologies in arable farming, livestock rearing and fishing to enable them to increase their productivity.

We on our part are determined to create the conditions which will enable Ghanaian farmers to make the best of their opportunities, for themselves and their families, and in the national interest towards sustainable food security. I know also that our farmers have proved themselves ready to respond.

You will learn, during this Workshop, of the modest advances which we have already made.

Mr. Chairman, Distinguished Delegates, in reviewing the work of Global 2000 in Ghana, the Sudan and Zambia, we will have the opportunity to share experiences and ideas for the benefit of the economically deprived throughout the world.

I am sure that all the representatives of developing countries gathered here today will share our conviction that there are two major ways in which the technologically advanced countries can help us.

The first is to channel their assistance into programs of this kind, programs which help the ordinary people to change their own lives through their own efforts, and which enable them to prove their own competence, productivity and creditworthiness in dignity, and not as objects of charity.

The second is to put their weight behind our just demands for a just world economic order, which will enable us to market the products of our toil for a fair recompense.

Your Excellencies, Ladies and Gentlemen, I wish the participants in this Workshop fruitful discussions over the next two days, and to all those engaged in meaningful endeavors such as Global 2000, I wish you continuing success.

Thank You.

Special Address

Flight Lieutenant, Jerry J. Rawlings
Chairman, PNDC, Government of Ghana

Mr. Chairman, Dr. Freymond colleague Members of the PNDC, President Carter, Mr. Sasakawa, Dr. Borlaug, distinguished Ladies and Gentlemen, fellow Countrymen and Women, our country has been honored by the presence of the distinguished participants at this workshop whose theme is crucial to us on this continent.

The Sasakawa-Global 2000 Agricultural Program has sought to help us increase productivity in two of our staple foods--maize and sorghum. No doubt you have been discussing this project not only in relation to Ghana but also in Sudan, Tanzania and Zambia, where similar efforts were launched around the same time. This is a humanitarian program designed to reverse the plight of the hungry and the dispossessed.

Ladies and gentlemen, the combination of the misuse of political, financial and scientific power, their capacity to provide the means to make unmake, have today contributed to most of our global problems. The solutions, therefore, cannot be found outside these three areas of influence.

These three men, Carter, Sasakawa and Borlaug, wielding political, financial and scientific power, have used it to do great good. It is our good fortune that they and their associates share a common dedication to humanitarian moral principles.

I would like to pay tribute to these three individuals whose vision and dedication have been largely responsible for the important initiatives we have been discussing.

President Jimmy Carter of the United States may have lost his bid for re-election in the U.S. Presidential elections in 1980, but his deep feelings for humanity continued to stir him to seek the good and welfare of fellow human beings in several continents. I may say that whilst the US lost a President, the world gained a selfless, dedicated humanitarian!

Ladies and gentlemen, the United States lost more than just a President, although I cannot tell how many Americans realize this. His very characteristics which were portrayed by his political opponents as weaknesses, as a too-soft attitude to defense, to Central America, to the Eastern bloc, to anything, in fact, which questioned the might-is-right philosophy, were in fact the signs that Jimmy Carter was in touch with the trend of the world's vibrations. He was already voicing, years earlier, with a religious tone, the same thoughts with which

President Gobachev is presently refocussing world opinions and attitudes.

Mr. Ryoichi Sasakawa, from his own humble origins in Osaka, Japan, at the end of the last century, and from the bitter experiences of world war, has put his wealth, and his life at the disposal of humanity, particularly those for whom famine, disease and poverty constitute the norm of existence.

Dr. Norman Borlaug, a man of great scientific and technological accomplishment, and a Nobel Peace Prize winner in 1970 for his work in initiating the Green Revolution in Asia during the 1960's continues, thankfully, to make improved technology available to farmers throughout the world.

Ladies and gentlemen, the question we should be asking is what was lacking in our own efforts before the arrival of the Global 2000 team? And the answer is obviously the human factor, that very simple dedication of men and women determined to attain set goals and determined to give expression to the best within us and in working selflessly to the upliftment of disadvantaged humanity to dignity and self-confidence. This is what has been lacking, and remains lacking in many aspects in other efforts--our own and those of various aid agencies.

If I were to attempt to explain why that essential ingredient has been lacking and all too often continues to be lacking, I could get into some long and complex arguments which we do not have time to explore today. But very briefly, I think that one significant cause of our problem in Africa is the attitude of many of us towards nation-building. Thus many of our people, be they agricultural extension officers, bankers, civil servants or any other official components of the system, still lack a sense of committment, of urgency, of dedication because at the back of their minds and unfortunately, a silly and inexcusable belief still lurks that they are working for institutions which are alien to them.

The other side of the coin is seen in the attitudes of many major donor agencies. Their combination of arrogance and condescension is another factor tending to undermine the chances of any sustainable success. Neither our attitudes nor their attitudes can provide that humanistic catalyst to make projects work as they should.

If we are to succeed in this country, on this continent, we must take ourselves to task for these weaknesses. And we who hold positions of leadership and trust must be especially awakened to the consequences for Africa's people of any lack on our part of dedication, of commitment and indeed of integrity.

Distinguished ladies and gentlemen, whilst paying tribute to Sasakawa--Global 2000, we must also salute the farmers whose eager response and hard work in the field have made possible the important advanced we are witnessing. In barely three years average yields obtained by thousands of farmers participating in the project in Ghana are three to six times what they would have been. With the display of a sense of responsibility that must be an example for our urban dwellers, the rate of loan recovery from the farmers is more than 90 percent.

And this is, indeed, a very sad commentary on the practices of our bankers, who have totally distrusted the peasant farmer and refused him the means to increase production to feed these very bankers and the nation at large. And yet these same bankers cannot even recover the loans which they extend to their cronies and relatives to finance petty trading instead of productive activity.

Ladies and gentlemen, we all feel pained about the attitudes of many of our educated elite who are blind to the realities of their own environment. How many graduates in agriculture have been willing to put their knowledge to work in the field with the farmer? And how many as farmers themselves have pointed the way with improved technology and with the skills derived from their education provided by the funds of these very farmers.

How many of our qualified doctors are not quick to show contempt for the very communities they have sprung from and go in search of material benefits elsewhere even though their education itself was paid for by the sweat of simple, hardworking farmers to whom they deny the benefits of their medical knowledge.

Ghana has many highly educated specialists in many fields as you know. And yet, in the simple outstanding success of Sasakawa--Global 2000 lies our weakness: management of already existing ingredients, the dedication and trust of people. If we have a shortage of dedication and trust, after all these years of independence, who can save us--who do we want to blame for our own irresponsibility?

The simple farmer who has never stepped into a classroom before is turning out to be the only one of our professionals who have achieved a truly revolutionary success. Those of us who have sophisticated knowledge in various fields but have been unable to apply it consistently, if at all, should admit our failings, and resolve not to ride on the backs of the farmers any longer.

Ladies and gentlemen, in giving its full backing to the Sasakawa--Global 2000 Project, the Government has long recognized its relevance to our commitment to reverse past policy failures that have contributed to the devastation of Africa's agriculture. We have left behind us the days of refusing to pay the farmer appropriately even when the world market price of his commodity was high, simply because of inappropriate exchange rate policies.

But we have also learnt over the years that the elimination of such unjust policies will not be, and is not, easy. We have also learnt from the realities of the unjust international economic order that hard work may often be barely rewarded. After several years of encouraging our cocoa farmers--on whom the task of earning foreign exchange for this nation has largely rested--we have seen a dramatic drop in world market prices, to about half of what it was in 1984.

Doubling our production figures has left us even worse off; nevertheless we will keep faith with the farmers who have suffered such injustice in the past. Our national recovery program depends on restoring the small-scale farmer to the center, not only of our agricultural and economic policy but also of our social

and political affairs, for it cannot make sense on a continent where about 80 percent of people are engaged in agriculture, that their social condition and their political participation are given such low priority.

For this reason our recent District-level elections have underlined our commitment to establishing democracy from the grassroots in our country. A radically decentralized system of public administration and national planning is also being created to underpin these steps towards restoring power to where it really belongs--with the people, not with me, not with the PNDC or any clique whether civilian or military administration. For us, the military as an institution, we are serving as an instrument for achieving this democracy and justice. The experiences of the past have been too painful to bear.

In furtherance of these aims, the fiscal policies of the Government will be directed to increase support to Sasakawa-Global 2000 and similar agricultural projects.

Distinguished ladies and gentlemen, I am also happy to announce that in appreciation of Mr. Sasakawa's contribution towards improvements in the lives of the disadvantaged people of the world the Government is honoring him with the Grand Medal of Ghana. This is a mark of the respect and gratitude of citizens of this country.

Distinguished ladies and gentlemen, let me express my pleasure again that this very distinguished gathering has taken place in Ghana in solidarity with our efforts to rebuild our country and our continent.

Africa's plight is not only an affront to humanity, it is also an indictment of our inability to come to grips with our own problems and a manifestation of the exploitative relationship which this continent has had to endure.

And unless the resources of technology, of wealth, indeed the very humanity of the rest of the world, are brought to bear on the problems of Africa to enable the continent and its people rediscover themselves, mankind will be the poorer.

Thank you very much.

Sasakawa - san
Omedetoh
(Arigato)

Introductory Comments

Ryoichi Sasakawa
Chairman, Japan Shipbuilding Industry Foundation

Chairman Rawlings, President Carter, distinguished colleagues and friends, good afternoon. It is with great appreciation that I welcome you to Workshop 1989--Feeding the Future.

It has been six years now since a devastating drought wreaked unprecedented famine in many nations of Africa. The tragic images of starvation and human suffering conveyed through the news media at the time shocked the Japanese public and evoked deep feelings of compassion.

My creed is that all the world is one family, and all mankind are brothers and sisters. As such, the pain and suffering of the African people is shared by every member of the human race.

Desiring to do something to ease the plight of my brothers and sisters in Africa when the famine broke out, I offered funds to send emergency provisions to Ethiopia. This aid took the form of what were commonly referred to then as "mercy flights."

But we felt a need to go beyond merely staving off the pangs of hunger--a need to carry out a revolutionary program that would attack the root of the hunger problem in Africa.

Therefore, seeking the assitance of Professor Norman Borlaug, who as the commander of the "Green Revolution" had previously contributed so much toward saving Asia from hunger, we convened "Workshop 1985" in Geneva under the theme, "Alleviation of poverty and starvation, and improvement of health: prerequisites to peace." My close friend President Jimmy Carter attended the conference and contributed his wholehearted support to its theme.

Out of that conference was born the "Sasakawa Global 2000 Agricultural Project," a joint project undertaken by President Carter and Professor Borlaug, whose presence we are honored with today, along with us in the Sasakawa Group. The Sasakawa Global 2000 Agricultural Project bore rich fruits in several African countries. Among them, it was the Republic of Ghana where the results of the project were most revolutionary.

What was achieved in Ghana was no less than a glorious victory in the fight against hunger. The battle was won through the diligence and hard work of the Ghanian people under the keen leadership of Chairman Rawlings. Indeed, the "Green Revolution" in Africa can be said to have begun in Ghana.

I believe a single action has more meaning than even a hundred hours of discussion. I urge you, friends and colleagues, to avoid discussion for discussion's sake, and use this conference to identify just what it is we can do to help our brothers and sisters in Africa.

Thanks to the cooperation so warmly accorded us by the Ghanian government, we are able to hold this conference in Accra. As we progress toward our ultimate goal of ridding Africa of hunger and starvation, let us build on the success which has already been attained here in Ghana. I look forward to discussions here over the next three days that will chart a practical course for us to follow in achieving our goal.

To Chairman Rawlings, the Federation of Ghana, and all of you in attendance today, I wish you productivity and prosperity.

Thank you very much.

Introductory Comments

Jimmy Carter
Former President of the U.S.A.

My first and overwhelming sentiment is to express my deep thanks to the Government of Ghana, to Chairman Jerry Rawlings, and Justice Annan, to the Secretaries of Agriculture, Health, Education, Transportation, and to all the others that have set a standard of cooperation and enlightened leadership that indeed can be, and is being, an inspiration to all other leaders in the developing world.

My second deep sentiment is of appreciation and recognition of the superb and enlightened leadership that has been shown by Mr. Ryoichi Sasakawa who has become a champion of progress among deprived people throughout the world. Mr. Sasakawa, we owe you a great debt of gratitude and recognition.

During this past week I have had the chance to travel in several parts of Africa with Dr. Norman Borlaug, who as you know is a Nobel Laureate, being given the greatest peace prize on earth in 1970 for his superb leadership in bringing about the Green Revolution in India and Pakistan. This week we have been to Khartoum in the Sudan, to Addis Ababa in Ethiopia, to Harare in Zimbabwe, to Lusaka in Zambia, to Lagos in Nigeria, and now here. And throughout the continent of Africa it is obvious that the principles that have long been espoused by Dr. Borlaug, and which have formed this wonderful partnership between him and Mr. Ryoichi Sasakawa, is teaching the world, and particularly Africa in this case, that the long-standing, food insecurity of Africa need not be permanent in nature.

There are a lot of statistics that can describe the plight of the African people. The most simple, at least for me, to understand is that it has taken us 30 years to double the production of food grain on this continent while the population of Africa is doubling every 20 years. So for the last two decades there has been a steady decrease in the amount of food produced in Africa for each person.

This has also resulted in a decline in the number of calories available to each African citizen. This not only is a painful cause of direct suffering because of starvation and malnutrition, but of many other problems that the Africans have recognized themselves, and that the world is only beginning to recognize, as being closely interrelated.

One of the benefits that I see coming from the Sasakawa-Global 2000 Sasakawa initiative is to let world leaders understand that there is a serious problem in Africa, but I think

equally, perhaps even more importantly, that it is a problem that can be and will be solved. The World Bank, the UN agencies, individual government aid programs, and the non-governmental organizations, need to be recruited to undertake projects based on the Sasakawa-Global 2000 principles, acting on their own initiatives, sometimes in a cooperative fashion in the future, to bring the benefits that we are recognizing today in Ghana to the other nations in this continent.

There are some principles that have been evolved, and basically I am just telling you what I have learned from Dr. Borlaug, that are absolutely imperative in any successful effort. The first requirement is that the top leaders in each country must be directly and personally involved. You cannot go into a nation and form an alliance only with the Minister of Agriculture and expect to be successful. It has to be with the President, the Prime Minister, the Minister of Agriculture, of course, but also the ministers of Finance, Education, Transportation, Health and perhaps others.

In the case of Ghana, this has been almost perfectly realized. As I talked to other leaders on this trip, I've told everyone that Chairman Rawlings is out in the field when farmers plant their corn and when they harvest it. He has the television cameras with him. When he goes to villages that have Guinea worm he demonstrates on television to his own people and now to many others, what must be done to correct this horrible affliction. So the top leadership in every country must be involved, because without that the prospects for success are minimal.

The second key to success in Ghana and in the future to other parts of Africa is that we must concentrate primarily on the small farmers--those who have one or two hectares of land. They are the ones who are the key to future increases in production. One of the most exciting things to me about the Sasakawa-Global 2000 projects has been the overwhelming enthusiasm of these small farmers, their competence and eagerness to work, their willingness to learn new ideas and to put them into practice and to share their successes with their neighbors. This grass root participation is a very important aspect of possible progress.

Ghana has been a remarkable experience for us all. The first time that Mr. Sasakawa and I came to Ghana was in January of 1986, when we agreed to launch a joint program to transfer improved technologies to small-scale farmers. That year we got a late start because we arrived just in time barely to plant a little maize and sorghum in the 1986 planting season. We had about forty farmers that were involved--roughly twenty with sorghum and twenty with maize. But they demonstrated to their neighbors, under the leadership of Dr. Eugenio Martínez and his coworkers, that they could be successful using very simple practices--the right seed, a moderate amount of fertilizer and adequate supervision.

On the average these farmers have been able to double and triple their production. In some cases they make four or five times more than they had ever made before in their lives. And therefore their neighbors watch them and they want to join so that

the next year, 1987, we went from forty to about 1,500. Last year was the third year. In 1988 we had 16,000 farmers, and as Mr. Sasakawa has pointed out, we now have 85,000 farmers directly involved in the Sasakawa-Global 2000 project, with more than 100,000 other nearby neighbors who are using some of the same practices because probably they see the successes that have already been realized.

Another very important aspect for permanent benefits to Africa is to let the native national leaders, extension workers and scientists be directly involved. It is not enough to let foreigners come into a country and take over a project. The best thing is to have a few come in with inspired leadership, like Dr. Martínez and his associates, and then have thousands of local people involved in the project.

That is what we do. With 85,000 farmers here in this country participating this year, we only have three people that are on the payroll of Sasakawa-Global 2000; in Zambia with tens of thousands of farmers, we have two people; in Tanzania, just one now, and two a little bit later on; in the Sudan only two staff as well. So what we are doing is sharing with local extension workers, the expert knowledge and experience of Dr. Borlaug and his scientists on how to integrate agricultural research into viable technologies and diffuse these among farmers. In a few years, when we move on to other countries, we hope to leave behind an adequate group of locally trained people who are superb.

The next thing I want to point out is the importance of good cooperation between research scientists, on the one hand, and extension workers and farmers, on the other. I have been a farmer all my life. My parents and my family, all the way back 350 years, have been farmers in my country. And I am very familiar with the research and extension work in my own nation and in my own state. Too often, there is a great chasm that exists between the technology being generated by dedicated and competent scientists in the research centers, on the one hand, and the transfer of those improved seeds and cultural practices on a broad basis among small farmers.

If the scientists have a kind of maize that will produce three times as much as a native ancient variety, they are more interested in finding a variety that will produce four times as much than they are to get the farmers to use the one they have already produced. And it is because of the fact that people like Dr. Martínez, and particularly Dr. Norman Borlaug, who transcend this division between research and production, that we are being able now to bring together the work of research scientists and extension workers to implement what the research centers are finding out.

As you may know, there are 13 major international research centers around the tropical and sub-tropical regions. Dr. Borlaug was associated with CIMMYT in Mexico, which is concerned with maize and wheat improvement. Another international center is ICRISAT, headquartered in Hyderabad, India, which works on Sorghum and millet. A third is IITA, in Ibadan, Nigeria, which works on tropical crops.

The next thing I would like to mention is that we have to go beyond just the rapid production of increased food supplies. We have got to have a way to store them. I was on a farm in Zambia recently, and the farmer told me he had never produced more 10 or 15 bags of maize per hectare. He had just finished harvesting 60 bags of maize per hectare. So we had to worry about how he is going to store and transport and market this increased supply of maize. This is a problem all over Ghana because we are rapidly increasing maize production. We have got to have a place to store it locally and at the national level, and hopefully, to build up in the near future an adequate export market. So Ghana will be selling maize--its surplus maize--to other countries at a great profit. This is one way that I see to overcome the horrible plight of foreign or external debt that is a burden for many African countries. Agricultural exports can be a major source of foreign exchange for countries that in the past have not even been able to supply food for their own people and were buying large quantities of food grain from other nations, therefore, building up their debt.

Another important thing that I think we need to realize is that there is no way to separate food production from other aspects of an individual or national life. We try to work with farmers to increase food production. We find often that in the same community there is a horrible blight of Guinea worm, or river blindness. Yesterday we had an all-day session in Lagos to talk about Guinea worm. In Nigeria alone, more than one million people have Guinea worm every year. And this affliction comes in the dry season when usually the harvest takes place. The farmers can't go into the fields, the children can't go to school, and agricultural production is severely decreased.

We ran an analysis just a few months ago in one small rice producing area in Nigeria of one and a half million people, and found that Guinea worm itself causes a reduction--listen to this--every year of twenty million dollars in rice marketed from that area. So you can see that the Ministers of Agriculture ought to be just as deeply interested in correcting the problem of Guinea worm as Ministers of Health. There is no way of separating the two. We have now got the World Health Organization, UNICEF and others to agree that Guinea worm will be the second disease in the history of human beings to be totally eradicated from the face of the earth; smallpox having been the first one. Dr. William Foege, Director of the Carter Center, was the one in charge of eradicating smallpox, and he has agreed to coordinate the worldwide effort to eradicate Guinea worm. Our goal is that by 1995, there will be no Guinea worm in any nation on the face of the Earth.

Just briefly to show you that is not the only case, river blindness is a terrible blight that comes to people who live alongside rapidly flowing streams and there are little flies that sting their arms or a person's body, a microorganism goes in and makes a person blind. In many villages, more than half the adults are totally blind. Over a period of 10,000 years or so the people, in order to avoid river blindness, moved away from the most productive land in the nation, just alongside the streams. Those few people that still live near streams often suffer from river blindness.

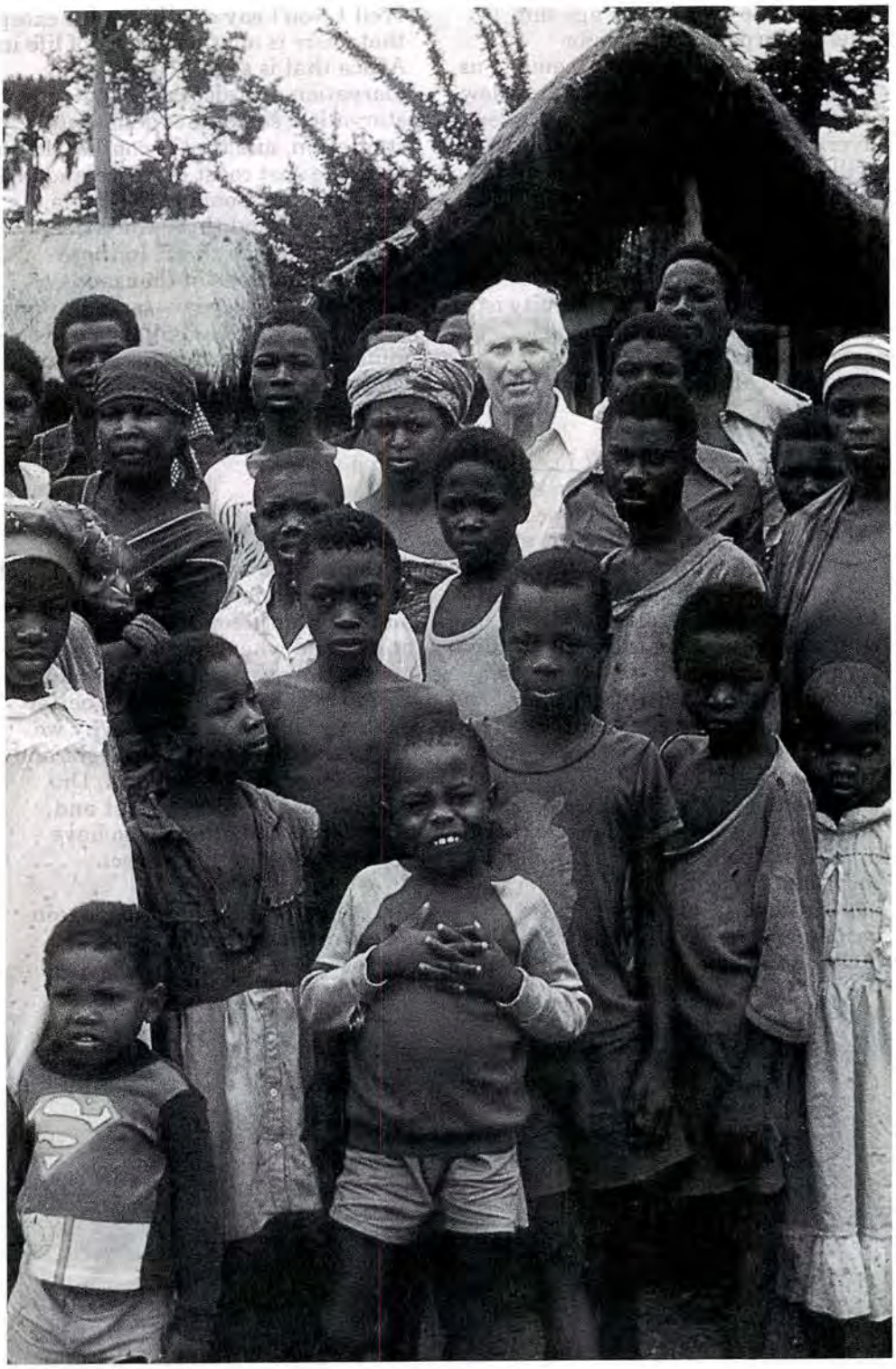
Just a little over a year ago the Merck Corporation, a major pharmaceutical company, came to us and said "if you will distribute a new medicine that we have found called Ivermectin--they call it Mectizan, "we will give this medicine free to all the nations on Earth in perpetuity." So now we are already distributing Mectizan to 20 countries, which is about two-thirds of the countries that have river blindness. The reality is you can't separate health from agriculture, from economic development, from environmental quality.

An finally, let me say that I certainly agree with what Justice Annan has said. Throughout the developed world--the rich world--there is a general presumption that their major obligation is to wait until starvation takes place so severely that dying children are seen on television. Only then do they marshall their forces, and out of the generosity of their hearts, quite often send millions of tons of wheat to the affected country. That is certainly a good thing to do in the case of a crisis. But it is not the best investment to prevent starvation in Africa. The best way is through the kind of program that Dr. Borlaug has initiated--a sustained, permanent, increase in the production of food grains throughout the continent of Africa.

Well I won't say anything else except that there is another aspect of life in Africa that is severly affected by starvation and also causes starvation, sometimes deliberate starvation, and that is conflict. If you go to the east coast of Africa and visit Mozambique, Somalia, Ethiopia, Sudan, you find those countries totally divided by war. In those nations hundreds of thousands of people die every year--some through direct combat, from bullets, bombs, mines--but most often because the combatants, the leaders of the opposing forces, deliberately withold food from starving people in order to win a victory.

So you can see that what Mr. Sasakawa has done, what Dr. Borlaug is doing and has done, is not only an avenue to provide more maize, or more sorghum, or more millet, and wheat but it is also a way to give the people of Africa, and indeed of the entire world, a better quality of life. And that is why we are so endebted to the foresight and generosity of Mr. Sasakawa, Dr. Borlaug, the Bank of Credit and Commerce, and others who have been involved in this project.

Mr. Sasakawa, Dr. Borlaug, again we express our thanks to you.



Overview of the Global 2000 Agricultural Projects in Africa

*Norman E. Borlaug**

This report provides an overview of the four agricultural development projects under way in sub-Saharan Africa and managed by Global 2000. Three of these projects are funded by the Sasakawa Africa Association (SAA), with grants provided by the Japan Shipbuilding Industry Foundation (JSIF), of which Mr. Ryoichi Sasakawa is Chairman. The fourth project is funded by the Bank of Credit and Commerce International (BCCI).

Genesis of the Projects

The famines that ravaged rural people in Sudan and some 20 other African countries in 1983-84 greatly shocked the world. One of the first to fly in food aid was the noted philanthropist, Mr. Ryoichi Sasakawa, Chairman of the Japanese Shipbuilding Industry Foundation (JSIF). Although a strong supporter of international disaster relief and world health programs, Sasakawa wanted to attack the underlying causes of Africa's food crisis, and not just the symptoms. Aware of the role that the high-yielding wheat and rice varieties and improved agronomic practices (especially the use of chemical fertilizers) played in averting widespread famine in Asia during the 1960s and 1970s, Mr. Sasakawa got it touch with me in late 1984 asking whether a "Green Revolution" could also be triggered in sub-Saharan Africa?

For nearly two decades, food production in most sub-Saharan countries has not keep pace with demand, as explosive population growth and declining soil fertility have overwhelmed traditional agricultural systems. Despite the fact that 70-85% of the people in most African countries are engaged in agriculture, most governments either have given agricultural and rural development a low priority or have pursued impractical, idealistic development goals.

Investments in input delivery and grain marketing systems and in agricultural research, extension, and education have been woefully inadequate and cheap food policies (costly subsidies) to appease the politically volatile urban dwellers have greatly distorted production incentives for farmers.

* President, Sasakawa Africa Association, and Senior Consultant, Global 2000

After consulting with research colleagues in national and international institutions, I was able to confirm that sufficient research products and information existed to greatly increase food production in most farming systems, especially those where annual moisture availability was above 700 mm. The main problem appeared to be that too few of these improved technologies were reaching farmers, especially the ubiquitous small-scale producers. Although continuing research was certainly needed to develop new and sustainable agricultural technologies for most farming systems, we had enough research products and information to begin the process of agricultural modernization.

Mr. Sasakawa said he was willing to fund several pilot projects in Africa designed to get improved agricultural technology into the hands of small-scale farmers. He asked me to assume overall technical leadership for these projects and to be responsible for selecting the principal staff.

About this same time, former U.S. President Jimmy Carter, also deeply concerned about Africa's food production crisis and looking for ways to help solve it, offered his collaboration and assistance, especially in the policy making arena so critical to overcoming the many problems plaguing agricultural development in Africa.

In January 1986, Mr. Sasakawa, President Carter, Dr. Leslie Swindale (Director General of ICRISAT), and I visited several Africa nations for discussions with government leaders about the prospects of establishing action-oriented, food crop technology transfer projects. We found strong interest for our proposals. In early 1986, we agreed to launch two agricultural development projects in 1986 in Sudan and Ghana. To manage these agricultural projects (along with other development projects, especially in primary health care), President Carter proposed that we establish a non-profit organization, christened "**Global 2000**," which became part of the Carter Presidential Center in Atlanta.

In late 1986, a third agricultural project was established by Global 2000 in Zambia, with funding provided by the Bank of Credit & Commerce International (BCCI), through the efforts of Mr. Agha Hasan Abedi, BCCI's President, who is the principal supporter of Global 2000's public health projects in Africa and Asia. In 1989, Global 2000 and SAA further expanded the network of agricultural projects by establishing a fourth project in Tanzania.

The Sasakawa Africa Association (SAA), of which I am President, is expanding its development activities in Africa. In 1988, SAA provided a grant to support the work of the December 31st Women's Movement in Ghana, especially its small-scale cassava chip food processing work at the village level. SAA is currently considering other agricultural and rural development projects in Ghana as well as other countries of Africa.

Program Philosophy and Distinguishing Features

While one blueprint does not fit all four agricultural projects in Ghana, Sudan, Zambia, and Tanzania, all share common philosophical and programmatic elements. First, all of the projects are concerned with improving productivity in staple food crops grown by small-scale men and women farmers. Second, we selected countries where we knew sufficient research products and information had been generated which were appropriate for small-scale producers, but which were not reaching them for various reasons. Third, each of the projects is quite small, both in terms of staff and financial resources. Two to three internationally recruited scientists are assigned to each country project, where they work with national counterpart staff in national extension and research organizations.

All of the Global 2000 project staff are highly trained, experienced agricultural researchers. This personnel policy was intentional and designed to give cooperating extension organizations more credibility with research organizations. We believe that technology generation and technology transfer process must be an integrated activity involving researchers, extension agents, and farmers. In most developing countries, information flows from research to extension are tenuous, and feedback mechanisms from extension to research are almost non-existent. We believe that it is time for extension to be accorded more prestige by agricultural research institutions.

The Project staff emphasize overcoming the most pressing constraints in staple food production first, before moving on to other agricultural problems and/or production opportunities. We are not waiting for the "perfect" technology before trying to help small-scale farmers. Rather, we believe that we can help the farmer take the first step toward increased productivity and better standard of living, by putting existing research products and information to work.

At present, soil infertility is the most-important factor limiting increased productivity in all four countries. With little organic manure available, the projects recommend moderate use of chemical fertilizers to restore soil fertility, in conjunction with improved varieties and more optimum agronomic practices so that farmers obtain greater returns to their investments.

Our field testing and demonstration programs differ from many other technology transfer efforts in several important ways. The first difference is the size of our demonstration plots, which are much closer to commercial scale. Depending on the country, our demonstration plots range from 0.4 to 2 ha, thus providing the farmer with a realistic test of the recommended technology and also offering a sizeable and immediate economic benefit. In Ghana and Sudan, the field demonstration plots are called production test plots (PTPs); in Zambia and Tanzania they are called management training plots (MTPs). Both are designed to let farmers evaluate the improved technology on their own fields and to train extension workers and farmers in the recommended crop management procedures.

The second difference is in terms of empowerment. We go beyond just providing information. We are prepared to provide the cooperating farmer, on credit, the inputs needed to grow the demonstration plot. So far, we have had better than a 95 percent recovery of these short-term production loans made to cooperating farmers.

The third difference involves the psychology of change. Our field testing program begins on a small scale and, if the results prove promising, is then expanded rapidly to a large scale to build widespread "grass roots" pressure on political leaders to get agriculture moving. By the 1989, only two to three years after our projects were conceived, several hundred thousand men and women farmers can be counted as direct alumni of the SG 2000 and BCCI-G2000 field demonstration programs.

The final difference between our approach to technology transfer and many other development programs is the activist stance that we take toward changing agricultural policy. We do not accept status quo. We are committed to influencing government investment decisions and to increasing the amount of capital flowing into agriculture. We seek to accelerate institutional and infrastructural development. We believe that poorly functioning technology delivery systems are a far more serious constraint today to increased food production in sub-Saharan Africa than the lack of improved technology, per se. Consequently, we are actively involved in lobbying political leaders to develop effective input supply and price strategies (fertilizer, improved seed, credit, and grain prices) needed to assist small-scale producers.

We try to keep small-scale farmers and their improved economic welfare at the forefront of our thinking and actions. Our task is clear: to make as many small-scale producers richer, more knowledgeable, and more in control of their economic destinies as we can. We know that agricultural technology cannot solve all of the social ills plaguing low-income countries. We are also aware that the technological change we advocate will invariably create some "losers" but we are convinced that there will be many more "winners." In the following pages, brief overviews are provided of our four agricultural projects. More detailed reports on the activities and accomplishments in these projects will be presented by the country staffs themselves.

Ghana Project

The Sasakawa-Global 2000 (SG 2000) Project in Ghana began in mid 1986, with an initial focus on improving maize and sorghum productivity. The Project has enjoyed the enlightened, enthusiastic and unwavering support of Ghana's political leaders. It is staffed by three expatriate scientists and one national scientist who is also the joint coordinator. Dr. Eugenio Martinez is the Country Director and Dr. Mathias Akposoe is the Joint Coordinator. During 1986-89, Dr. Chong Woon Hong, a soil scientist, played a major role in the

development of the project. Dr. Marcel Galiba, a plant breeder, has been with the project since 1986. In May 1989, Ing. Astorfo Fumagalli, a Guatemalan agricultural research leader, joined the project as the replacement for Dr. Hong.

The coverage of the Ghana field testing program has expanded from two regions in 1986 to all 10 regions of the country. By the end of 1989, more than 100,000 farmers will have participated directly in the field testing program, while two to three times more farmers could be considered as indirect participants. Recommended technologies include the use of high-yielding seeds, moderate amounts of chemical fertilizers, and improved cultural practices--especially planting methods and weed control. Average yields obtained by participating farmers have more than doubled and profits have more than tripled.

SG 2000 production recommendations are based on research conducted by the Crops Research Institute (CRI) and the Soils Research Institute (SRI), both headquartered at Kumasi. These institutions have done some excellent work in developing improved varieties and production recommendations. They have also benefitted from more than a decade of fruitful research and training collaboration with several international centers, especially the International Maize and Wheat Improvement Center (CIMMYT), the International Institute of Tropical Agriculture (IITA), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and the International Fertilizer Development Center (IFDC).

Through 1988, over 90 percent of PTP cooperators have repaid the cost of inputs they have been provided. This loan recovery rate is perhaps the strongest evidence of the appropriateness and profitability of the recommended technologies. This fact has not been lost on Ghana's banking community. Whereas in 1986 no Ghanaian banks provided agricultural credit to small-scale farmers today three banks are now involved in providing credit to PTP farmers: the Agricultural Development Bank, the Ghana Cooperative Bank, and the Ghana Commercial Bank. Increasingly, these banks have expanded the number of PTP farmers to whom they are granting loans: 200 PTP farmers in 1987, 7,000 in 1988, and 25,000 farmers in 1989.

Currently, Ghana is considered by the World Bank to be model country in its efforts to revive the national economy. The Bank has provided considerable support to the government's economic recovery efforts. Partly as a result of SG 2000 project activities, the World Bank has recently made a loan to Ghana of $164 million over three years to cover various agricultural and rural development needs. Loan funds are being used to encourage expansion of grain storage capacity, especially at the district level and regional level. Some of this grain storage capacity will also be used for fertilizer storage in off season. The World Bank is also financing improvements in Ghana's

road networks, reforestation programs, cash crop development, and agricultural credit systems.

Ghana already has initiated a process to privatize fertilizer supply. In 1989 the retail level will be privatized; in 1990 the wholesale level; and in 1991 international imports will be handed over to the private sector. In 1989, fertilizer prices increased by 45 percent as the government removed most of the previous subsidy. Because of the significant transportation costs involved in the delivery of fertilizers to the farm-level, it is important for Ghana to switch to higher analysis nitrogen fertilizer products, such as urea (46% N) versus the presently imported ammonium sulfate (21% N). This switch can reduce farm-level costs for nitrogen--the main nutrient required--by 25-30 percent.

Effective seed production remains a persistent problem for Ghana. The Ghana Seed Corporation (GSC) is barely functioning. In the interim, semi-commercial seed production activities have been carried out by the Ghana Grains and Legume Board and by SG 2000. These efforts have helped to deliver improved seeds to farmers but should not be viewed as a long-run substitute for a functioning seed industry capable of producing quality certified seed and distributing it to farmers in a timely way.

Ghana has a good research program for maize and cowpeas, which has been strengthened during the past decade through a grant from the Canadian International Development Agency (CIDA) which has funded the Ghana Grains and Legume Project, under which CIMMYT and IITA have placed staff in the country. CRI has released some excellent open-pollinated maize varieties and developed some good sets of improved crop management practices. In recent years, outstanding national varieties have been improved for resistance to Maize Streak Virus (MSV) through a joint IITA-CIMMYT effort. IITA is also active in the development of maize hybrids with resistance to MSV. Continuing research is needed on various multiple cropping sequences in maize-based farming systems, on soil conservation and fertility maintenance, and on post-harvest grain storage.

CRI's efforts in cowpea improvement, while less advanced than in maize, have also make good progress. IITA has played an important role in developing higher yielding cowpea varieties; more work is still needed to enhance insect and disease resistance before these high-yielding varieties will be widely accepted by farmers. Good opportunities also exist for grain-legume rotations and relay cropping systéms; more research should be conducted on these cropping patterns.

CRI's sorghum research is headquartered at its experiment station located in the Guinea Savannah at Tamale, Upper East Region. West Germany's GTZ organization is an important financial supporter for sorghum (and millet) research and ICRISAT is providing technical backstopping. Considerably more sorghum

research is need in Ghana to develop higher yielding varieties with good disease resistance and tolerance to drought. Framida, the sorghum variety recommended in the PTPs, is about the only improved variety that is resistant to head mold and somewhat tolerant of the parasitic weed, striga. Framida is quite an old improved variety and is not particularly high-yielding. Even so, it is more responsive to improved soil fertility than the local variety, Boku white. Because of its superior yield potential farmers are using Framida, even though its grain does not have the preferred white color. Several high-yielding white grain hybrids and varieties have been identified in the past two years; susceptibility to head mold, however, have kept them from being released and recommended for commercial production. Clearly, more investments are needed in sorghum and millet improvement, given the importance of these crops in Ghana's savannah areas.

Sudan Project

Sudan, Africa's largest nation in land area, has long been touted as the potential granary for the Horn of Africa and the Arab world. Several million ha are potentially suitable for irrigation from tributaries of the Nile river. Large rainfed land tracts are also suitable for sorghum and millet production (in the eastern regions between the Nile Rivers and Ethiopia) and for maize production (in the southern regions). Despite Sudan's tremendous potential for food production, the state of agriculture is not good. The situation has worsened in recent years because of the civil war.

The SG 2000 Project in Sudan began in May of 1986 with an initial focus on sorghum, millet, and wheat improvement. The Project has been staffed by three expatriate scientists: Dr. Ignacio Narvaez, Director; Dr. Marco Quiñones, Senior Scientist; and Dr. Jose Antonio Valencia, Scientist. In 1989, Dr. Quiñones left the project to become Country Director of the newly established SG 2000 Project in Tanzania.

After the 1987-88 crop year, the SG 2000 staff discontinued their work on millet improvement. Two factors prompted this decision. First, after two years of field testing, it was determined that we lacked appropriate technologies to make significant impacts upon production within acceptable risk levels for the small-scale farmer. Harsh environmental conditions in many areas where millet is grown (200-300 mm of rainfall during the growing season) are simply too formidable for science to overcome with presently available knowledge. Second, the deteriorating internal security situation in the western region--where most of the millet is grown--made it very difficult for our staff to carry on an adequate field demonstration program.

Project staff now concentrate their activities on sorghum and wh t improvement in the irrigated areas adjacent to the White and Blue Nile rivers. This region includes more than a million hectares of cultivated land. Sudan's irrigated areas remain underdeveloped with low food crop yields despite the tremendous potential for higher yielding and more profitable production systems. The irrigation canal systems are in

serious disrepair due to silting, heavy weed infestation, seepage, animal damage and broken auxiliary pumps. Other important production constraints are lack of inputs (especially fertilizer and seed), and problems in the timely availability of farm equipment for land preparation and harvesting.

The technology being demonstrated in the SG 2000 field testing program was developed by Sudan's Agricultural Research Corporation (ARC) in collaboration with the International Center for Agricultural Research in Dry Areas (ICARDA), CIMMYT, and ICRISAT. SG 2000 project staff have worked closely with sorghum and wheat scientists at ARC and have made several contributions to the stock of research knowledge, especially the value of phosphorus fertilization on wheat and sorghum and the need for improved seed bed preparation to assure good standings of seedlings.

The recommended sorghum production package for irrigated areas includes the use of the hybrid variety, Hageen Dura-1, moderate application of chemical fertilizers, and proper cultural practices (good land preparation, timely planting, proper seeding rates, control of weeds, and timely irrigations). Hageen Dura-1 was developed by ICRISAT (employing a Texas A & M University A-line as the female) in cooperation with ARC. During the 1988 sorghum season (July-October), the Project's demonstration plots covered 1,200 ha (2,900 feddans) and involved more than 1,000 farmers. The average yield from the 1988 demonstration plots (size = 1.1 ha per farmer-cooperator) was 3.1 t/ha, three times the traditional yield for this area. An important contribution of SG 2000 has been the active promotion of Hageen Dura-1 and moderate use of nitrogen and phosphatic fertilizers. As a result of the Project's efforts, sufficient seed has been produced to plant more than 25,000 ha in the 1989 summer season--a ten-fold increase over 1988.

Increased wheat cultivation, although originally viewed as a secondary priority in the SG 2000 strategy in Sudan, has become a major objective. During the 1988-89 winter season, The Project's wheat demonstration plots covered nearly 1,175 ha and involved 575 tenant farmers (2.1 ha per cooperator). Most of the demonstrations were planted in large blocks involving groups of 10 to 20 individual tenant farmers. The average wheat yield on the production test plots in the 1988-89 season was 3.1 t/ha, some two and a half times greater than the national average. Several demonstration plots yielded above 5.5 t/ha, a remarkable yield considering Sudan's high temperatures and 110-day growing season. The SG 2000 team has been instrumental in diffusing the most recently released high-yielding wheat variety, Debeira, and improved cultural practices, especially better land preparation and more balanced fertilizer applications (e.g. the addition of phosphatic fertilizers). Debeira is an Indian variety based on germplasm developed at CIMMYT and supplied by ICARDA. Sufficient seed of Debeira was produced on the demonstration plots this year to plant 70,000 ha next year. Seed of the improved wheat variety, Condor, the other high-yielding variety heavily promoted by the project, should be available to plant 125,000 ha next year. Condor is an Australian variety based on CIMMYT germplasm.

The SG 2000 Project in Sudan has had a remarkable impact, given the country's recent political and economic crises. Project staff enjoy the respect of the farmers, extension workers, researchers, and government officials with whom they have worked. Farmers have enthusiastically adopted the sorghum and wheat production recommendations demonstrated through the Project. Agricultural policy makers in Khartoum have also become more aware that significant increases in wheat production and rural welfare are possible through the diffusion of improved technology. Sudan's political chaos and instability (five Ministers of Agriculture in less than a year) and the continuing civil war in the south still have a stranglehold on national development efforts to increase food production.

Currently, Sudan has nearly a one million ton deficit in wheat production brought on by the rapidly growing urban population who have a preference for bread. A Technical Committee for Wheat Self-Sufficiency was formed in October, 1988, by the Council of State to devise a plan to achieve self-sufficiency in wheat and bread production within five years. The Committee has presented a comprehensive list of resource requirements to the Council of State to meet these production targets. The nation's irrigated wheat area is to expand from 160,000 to 320,000 ha, and average yields are to increase from 1.3 to 2.4 t/ha. The sorghum hybrid, Hageen Dura-1, produces an excellent flour suitable for the production of bread by mixing in proportions up to 25% with wheat flour. Use of this hybrid could help reduce Sudan's dependence on imported wheat and wheat flour.

Zambia Project

The BCCI-Global 2000 agricultural project in Zambia began in late 1987 in association with the Ministry of Agriculture and Water Resources and its Department of Extension. The Project is staffed by two expatriate scientists: Dr. R.P. Jain, Country Director, and Dr. Abu Michael Foster, Scientist. In mid 1989, Dr. Foster left to become a senior scientist in the newly established SG 2000 project in Tanzania. He has been replaced by Dr. Tareke Berkhe, who assumes his new position in August, 1989. The national counterpart is Mr. C. Masi who replaced Mr. M.N. Chiinda, who left to further his studies in the United Kingdom. Funding for the project is provided by BCCI, London, and by the BCC Foundation in Lusaka. Project staff are now working in the Copperbelt, Central, Lusaka and Southern provinces.

Maize is the most important food crop in Zambia. It is grown in most regions of the country with adequate rainfall and reasonably fertile soils. Sorghum is of secondary national importance but of regional importance in lower rainfall areas. Land in Zambia is not a constraint and generally belongs to the various tribes and is available to their farmers who ask to use it. The average amount of land available to a Global 2000 farmer is about 4 ha. But because of labor shortages and difficulties in hiring help, most farmers only cultivate 1-2 ha with their traditional implements--the hoe and cutlass. Tractors are still not viable for most small-scale farmers. The use of oxen for animal traction, however, do have a future for small-scale producers in areas where tsetse fly or East Coast Fever are not a problem.

Zambia has a dualistic food production sector, comprised of a relatively few large-scale commercial farmers--many who are former colonialists--and many small-scale, near-subsistence farmers. The larger farmers use modern methods of production, including hybrid seed, fertilizers, farm machinery, and agricultural credit. Small-scale farmers remain largely outside the commercial economy; they purchase few inputs and sell little of their production. The project is focused on bringing the benefits of improved food production technology to these resource poor farmers.

During the 1988-89 season (October-April), approximately 5,700 maize and sorghum management training plots (MTPs) and 21,000 one-hectare commercial production plots have been planted in cooperation with farmers and extension workers in three provinces. The commercial production plots are grown by former Global 2000 farmers through input credit provided by their Co-operative Unions.

BCC Ltd makes the loan to the Co-Operative Union, which, in turn, buy the inputs, manily seed and fertilizer which are supplied on credit to the participating farmer to plant one hectare. Participating farmers are selected and supervised by their local extension officers while bank credit officers monitor the loans made to the Unions. After harvest, the farmer is expected to repay the production loan to the Co-Operative Union which, in turn, repays BCC Ltd. A special set of incentives have been established for the supervising extension officers which are paid in recognition of farmer repayment rates above 95 percent.

BCC Ltd first provided credit to 2,200 Global 2000 farmers in 1987-88. The success of this first venture led them to expand the program in 1989-90. Although I do not have the final loan repayment figures repayments for this year, considering the excellent condition of the crop, I expect that the loan recovery rate will be high. I compliment Mr. A.R. Khan, BCC Ltd's Managing Director, for his leadership and vision in establishing this credit program.

Zambian research institutions have developed some excellent hybrid maize varieties as well as some good improved sorghum varieties. Research institutions have also developed good production practices for food crop production, a fact evident in the relatively high average national maize yields. The technology delivery system works quite well for the larger commercial food crop producers. The national seed corporation, Zamseed, produces a significant volume of hybrid seed, sufficient according to official reports to plant half of the total national maize area. Hybrid maize seed (SR 52 and derivatives) is also imported from Zimbabwe and is available in some areas. Fertilizer supply is a problem and shortages of the right kinds and amounts frequently occur. Fertilizer delays are mainly caused by delayed unloading due to congestion in the port and delays in rail transportation from Dar es Salaam. Credit is usually available for the larger producers but not the small-scale farmer. The primary food production problem for small-scale producers in Zambia is that the technology delivery system does not function properly for them.

Price policy is a serious problem in Zambia. The real price for maize in Zambia is much below the world market price and food subsidies are higher in Zambia than any other country in Africa. In 1988, the amount of maize milled in Zambia was about 30 percent greater than consumption, evidence that large amounts of maize meal are being smuggled across the border to Zaire. With current price policies, the government of Zambia is, in effect, subsidizing Zairean consumers.

Despite a stable government under President Kenneth Kaunda, Zambia has suffered a series of economic blows during the past several years. In May 1987, the government broke with the economic austerity policies of the International Monetary Fund (IMF). In response, the World Bank and the IMF refused to make further funds available. The government announced its own interim development plan in 1987 which was to run through the end of 1988. This plan attempted to remove many subsidies, including the subsidy on maize meal, which prompted food riots in Lusaka in 1988 and forced the restoration of the subsidy.

Tanzania Project

The SG 2000 Project in Tanzania was initiated in early 1989. It is led by two expatriate scientists and a national counterpart to be appointed by the Ministry of Agriculture. The Country Director is Dr. Marco Quiñones and Dr. Abu Michael Foster is the Senior Agronomist.

Three main operational zones have been identified, in consultation with government officials. These zones include (1) the northern highlands focusing on the Arusha region, (2) the central plateau focusing on the Dodoma region, and (3) the Southern highlands, where the target region is yet to be determined. In these operational areas, the promotion of improved maize or sorghum production practices will receive the major emphasis.

Maize research in Tanzania has been focused on three agroecological zones: (1) the lowland zone, including coastal areas and other areas below 900 m elevation (2) the mid-altitude zone between 900 and 1,500 m which is divided into two sub-zones: a) areas with more than 1,000 mm rainfall and a longer growing season and b) areas with less than 1,000 mm rainfall and a shorter growing season, and (3) highland areas above 1,500 m elevation which generally receive adequate rainfall and have long growing seasons (most of Tanzania's maize is grown here). Maize streak virus (MSV) can be a serious problem in the lowland and mid-altitude zones, and leaf blotch (H. turcicum), ear rot, and stalk borers can be serious problems in the high-altitude zones.

The SG 2000 Project in Tanzania uses a similar nomenclature for its demonstration plots as in Zambia. Participating farmers in the Tanzanian management training plots (MTPs) will receive technical advice and will provided inputs on credit provided by SG 2000. The MTPs are strategically located to permit easy access by farmers during the initial years.

The recommended technologies are based on research products and information provided by the Tanzanian national agricultural

research service with technical assistance from CIMMYT. The recommendations include the use of improved varieties and hybrids, moderate amounts of fertilizer, improved cultural practices. The second phase is to move farmers into commercial production channels in which they secure their own inputs. Discussions have been initiated with leaders of the Co-operative Unions and financial lending institutions to develop a credit program similar to the BCCI program in Zambia.

The field testing and demonstration program was initiated in early 1989 in the Arusha Region of the northern highlands. The field program in the central plateau and southern highlands will begin in November, at the start of the 1989-90 season.

West African Project Expansions

There is growing interest in our approach to technology transfer in several other West African counties. We are especially interested in developing new activities in the Francophone countries. In March, 1989, I visited Benin and had extensive discussions with President Mathieu Kerekou. We agreed to plant 60 PTPs in sorghum and maize in this year. Depending on the outcome of these field tests, we may expand our collaboration with Benin. Togo has also expressed interest in establishing a similar technology transfer project and we are interested in exploring this possibility as well.

Feeding the Future: A Green Revolution for Africa

One can dream of the day, as I did almost 20 years ago in my acceptance speech for the Nobel Peace Prize, when advances in science will have produced cereal varieties which are resistant to all major diseases and pests, tolerant to abiotic stresses such as drought, higher in protein and with balanced amino acid compositions, and which can fix their own nitrogen from the air, greatly reducing the need to apply chemical fertilizers. Although I believe that many such breakthroughs eventually will come, it is highly unlikely that they will be achieved this century or even in the next 30-40 years.

To help alleviate poverty and human suffering in sub-Saharan Africa during the next 20 years, we must rely on technologies already available or well advanced in the research pipeline. These technologies have brought tremendous benefits to First World nations, where food supplies are plentiful and inexpensive. The failure to comprehend this fact will have disastrous consequences for the people of Africa.

Too many national and international government officials still seem to think that once the droughts are over, agricultural production in sub-Saharan Africa will promptly recover and harvests will again be sufficient for people's needs. This is not so. Africa's food production crisis is the result of several decades of explosive

population growth and misguided development plans which gave far too great a weight to industrial and urban development and too little priority to agricultural and rural development.

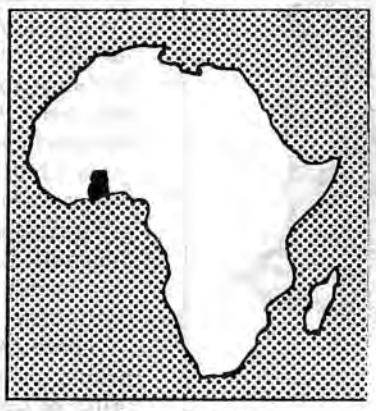
Unless drastic changes occur in recent trends, the U.N. Food and Agriculture Organization's alarming prediction that sub-Saharan Africa will only be producing 75% of its food production needs by the year 2000 will become a tragic reality. Such a scenario will mean human suffering, social and political upheavals, and environmental degradation on a scale not seen in this century.

This disaster need not happen. It can be prevented if agricultural researchers, extension workers, and educators commit themselves to serving farmers and if heads of governments aggressively implement programs to modernize agriculture and rural areas.

The Sasakawa-Global 2000 Agricultural Project in Ghana

*E. Martinez, M.K. Akposoe, M. Galiba, and C.W. Hong**

Introduction



The Sasakawa-Global 2000 (SG 2000) Agricultural Project in Ghana aims to increase cereal production by transferring improved agricultural technology to small-scale farmers. Past attempts aimed at introducing productivity-enhancing technologies have met with limited success in Ghana, as evidenced by the poverty, malnutrition, disease, and illiteracy, especially in rural areas. This state of affairs has been a matter of grave concern of various administrations. The current economic recovery program of the government of Ghana has made the introduction of productivity-enhancing technologies among small-scale producers one of its central agricultural development strategies.

SG 2000's primary objectives are to (1) assist the Ministry of Agriculture to mount a large-scale technology demonstration program to introduce improved food crops technology to small-scale producers, and (2) to work with government of Ghana officials to strengthen the nation's agricultural technology delivery systems in extension, input supply, credit, and price policy.

SG 2000 project staff work with Ghana's Ministry of Agriculture, principally through the Extension Service. SG 2000 activities are guided by an National Advisory Committee, with representation from key agricultural research, extension, production, credit, and policy organizations. SG 2000 employs three expatriate scientists in Ghana; the government of Ghana also has deputed a National Joint Coordinator, who works full time within the SG 2000 project.

SG 2000's field program has been divided into three geographic zones of operation as shown in **Figure 1**: **Northern Zone** (Upper West, Upper East, and Northern regions); **Central Zone** (Ashanti and Brong-Ahafo regions); and **Southern Zone** (Western, Central, Eastern, Volta and Greater Accra regions). A senior SG 2000 staff is assigned to each zone and works closely with the Deputy Secretaries of Agriculture that head the Ministry of Agriculture's activities in each of Ghana's 10 administrative and political regions. SG 2000 staff work directly with regional and district extension service personnel in the implementation of the field testing program with participating farmers.

* SG 2000 Country Director, National Joint Coordinator, Senior Scientist, and Senior Scientist, respectively

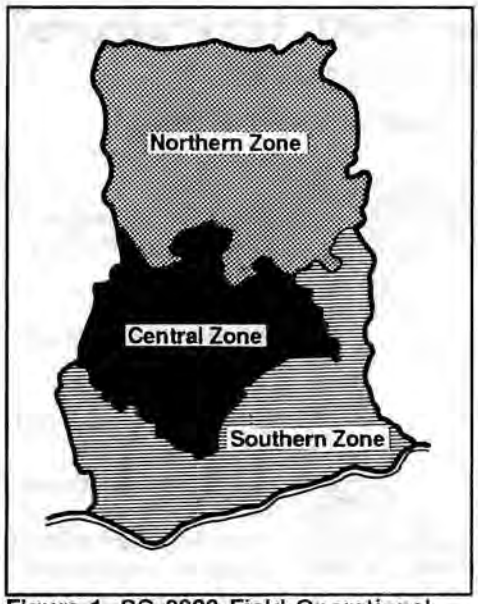


Figure 1. SG 2000 Field Operational Zones in Ghana

Project Methodology

Dr. S. A. Knapp, the founder of the U.S. agricultural extension service, based his technology transfer strategy in the early 1900s around the concept of farmer-managed field demonstrations in the belief that "what a farmer hears, he generally disbelieves; what he sees, he may also doubt; but what he does himself, he cannot deny." Knapp's philosophy is strongly embedded in the SG 2000 technology transfer strategy. Diffusion of technology is a dynamic "process by which an innovation is communicated through certain channels, over time, among members of a social system" (Rogers 1983). Four characteristics are important to insure the adoption and diffusion of a technology: relative advantage (more grain yield, profit), compatibility (maize and sorghum are staple food grains), non complicated (in the realm of farmer's comprehension) and trialability (farmer managed test plots).

The SG 2000 technology transfer strategy turns around the "Production Test Plot" (PTP), which is approximately 0.4 ha in size (one acre) and is grown using the recommended package of production practices. Along side of the PTP, the farmer is asked to grow a second plots, using traditional farmer practices (FP), to help in making comparisons. A volunteer farmer is given the opportunity to try and observe the innovations during a growing season in order to take a decision. Basic inputs are provided on a credit basis to be paid in kind or cash after harvest. SG 2000 is not involved in land acquisition and land preparation which are the responsibility of the participating farmer.

Each PTP farmer should invite at least 10 neighboring farmers to form a cluster to help evaluate the recommended production package and, hopefully, to serve as future "change agents" in helping to diffuse the improved technologies throughout the farming community. Field days are held at various PTP sites and attended by local farmers, agricultural officers, opinion leaders, and the general public. They are held during important stages in the growth cycle of the crop. On these occasions, the cluster center farmer is encouraged to lead the discussion and answer questions. This principle not only places responsibility on the farmer, but also generates confidence and pride, essential contributory factors to acceptance of the technology.

Farmers are directly involved in the PTP grown on their land and participate in all of the cultural practices associated with managing the crop. Cluster farms represent the focal point for PTP activities. Communication proximity, "degree

to which two individuals have overlapping communications network," is very high between members of the same village. Information is expected to flow from the PTP (and technical officer) to the farmer clusters. The production problems encountered by the farmers with the new technology are expected to flow back up through the extension service to the research service. After a successful growing season, the cluster-center PTP farmer "graduates" and moves from the PTP to a normal Production Plot (PP). Most of the time, the whole cluster joins the graduate and starts forming an association in order to follow the new technology.

The success of the SG 2000 extension strategy is mainly due to the profitability and simplicity of the recommended technological packages, and the fact that technical information and the requisite inputs are provided that, in effect, empower the farmer to test and adopt the technology. The PTP yield advantage has generally been so obvious that farmers have had little doubt about the superiority of the recommended technological packages. The SG 2000 credit scheme is also very simple. Farmers receive, inputs (seeds, fertilizer) and not money on time and at their farm gate. They have the option of paying for their PTP loan in kind (at the guaranteed minimum price) or in cash. SG 2000 is not only transferring the information about a new technology, but it also is providing the farmer with the means for adoption.

Southern Zone

The SG 2000 field program began in Southern Ghana in 1987 in the Central, Eastern and Volta regions with the establishment of approximately 90 maize PTPs: 21 in the Volta, 25 in the Central, and 44 in the Eastern region. Mean grain yield from these maize PTPs in 1987 was 2,800 kg/ha, almost three times higher than Ghana's national average. The number of maize PTPs and PPs planned for 1989 and 1990 are 27,500 and 92,000, respectively (**Table 1**). To date, all of the PTPs have focused on demonstrating improved maize technologies to small-scale producers. Over time, new crops, cropping patterns, and agronomic practices will be tested and demonstrated through the program, as researchers develop new technologies.

Table 1. Evolution in Number of PTPs in Southern Zone

Region	1987	1988	1989*	1990*
Central	25	500	8,000	30,000
Eastern	44	569	8,000	30,000
Volta	21	700	10,000	30,000
Greater Accra	-	15	500	1,000
Western	-	20	1,000	1,000
Total	90	1,804	27,500	92,000

* Projections

Results of the 1988 Field Program

In 1988, farmers in the Greater Accra and Western regions also jointed the program, and the number of PTPs grew to 1,804--a 22 fold increase.

Performances of Recommended Varieties--Three open-pollinated maize varieties were used in the PTP program: Safita-2 (95 days to maturity). Aburotia (105 days) and

Dobidi (120 days). A survey taken during 1988 of 1,054 farmers revealed that Dobidi was used by 80 percent of all farmers in the Southern Zone, while Aburotia was used by 15 percent and Safita-2 by 5 percent (**Table 2**). Wherever rainfall was adequate to support a long growing season, Dobidi was the preferred variety. Safita-2 was prevalent only in Denu district (89% coverage) because of the short and erratic rainfall patterns of the area. Along the lower rainfall Coastal Savannah area, the slightly longer duration maize variety, Aburotia, was preferred.

Recommended plant spacing in the maize PTPs was 90cm between rows and 40cm between hills, with two plants per hill, giving an optimum population density at planting of 55,000 plants/ha without thinning. Such optimum plant densities, however, were rarely achieved by the participating farmers. Population density of less than 40,000 plants/ha were encountered with all three recommended varieties. The PTPs growing Dobidi had the lowest actual plant density with 67 percent of optimum density, followed by Safita-2 with 68 percent, and Aburotia with 71 percent (**Table 3**).

Planting was done by hand with a planting stick, hoe or cutlass. Spacing between rows was easier to follow because of a garden rope or siting poles contrary to spacing within rows done more by judgement. This situation led to a tendency to plant a lower number of plants than needed. Only Mfantsiman district had a optimum population density (59,500 plants/ha). Density as low as 25,000 plants/ha, only 45 percent of optimum population density, was recorded. Considerable scope still exists, therefore, to increase yields by 20 to 30 percent by increasing plant population density.

Variability for grain yield was great. Mean grain yield ranged from 2.7 t/ha at Denu, where weather conditions were poor, to 6.3 t/ha at Mfantsiman, where highest population density was recorded. An overall average grain yield of 15 bags/acre (of 100 kg each) was obtained from the PTPs, more than three times the average yield of the farmer's traditional technology (4 bags/acre) (**Table 4**).

Land Preparation and Plot Size--Date of land preparation was measured as number of days after March 1st. Eastern Region farmers started land preparation very early:

Table 2. Use of Maize Varieties in Southern Ghana

Region	Dobidi %	Aburotia %	Safita2 %
Western	65	35	-
Volta	81	7	12
Eastern	87	10	3
Central	67	33	-

Table 3. Population Density of Improved Varieties in PTPs at Harvest Time

Region	Dobidi plants/ha	Aburotia plants/ha	Safita-2 plants/ha
Western	36,300	38,000	-
Central	30,500	47,000	-
Eastern	39,300	41,000	36,700
Volta	43,000	33,000	39,500
Mean	37,275	39,750	38,100
% of optimum Population density	67	71	68

in Yilo Krobo district, it was as early as February 3rd. Some pockets in Swedru and Ajumako districts of Central Region did the same (**Table 5**). The latest land preparation was observed in Volta Region; mean value of 100 days was found between first and last date of land preparation. Range values of 120 and 116 days were measured in Jasikan and Kwanta districts of Volta Region. Eighty four percent of all plots were slashed and burnt. Nine districts out of 19 had a "slashed and burnt" percentage of 90 percent or more. It appeared that tractor use was rather the exception than the rule. However, Asuogyaman and Winneba districts had the lowest percentage of slashed fields with 29 percent and 38 percent. Plot size did not show much variability. Average plot size was 3,547 m^2, close to one acre; no plot was below 1,000 m^2 (**Table 5**).

Planting Time, Stand Establishment, and Intercropping Patterns--The earliest maize plantings begin in the Eastern region followed by the Central, Western, and Volta region (**Table 6**). Range value of nearly 100 days was found in Volta Region for planting time. In Kpandu, Jasikan and Kwanta range values were 125, 108, 107 days, respectively. Asuogyaman and Swedru districts planted as early as March 1st. Knowing farmers habits concerning land preparation and planting can help to plan ahead input carting and delivery to avoid any delay. Results found during 1988 growing season confirmed those observed in 1987: Eastern region should be the first region to receive inputs, followed by Central, Western and Volta Regions.

Thirty two percent of all plots were replanted (or refilled) (**see Table 6**). The situation was worst in Volta and Central regions, with a mean percentage for replanting of 46

Table 4. Performance of Recommended Maize Varieties in PTPs, Southern Zone

Region	Dobidi kg/ha	Aburotia kg/ha	Safita-2 kg/ha
Western	4,700	3,800	-
Central	4,100	3,800	-
Eastern	3,850	3,900	3,200
Volta	3,900	3,400	3,800
Zonal Mean	4,137	3,725	3,500
Mean (bags of 100 kg/acre)	16	15	14

Table 5. PTP Time of Land Preparation, % of Slashed and Burnt Plots, and Average Plot Size, Southern Zone

Region	Time of land Preparation (# days after March 1st) Minimum	Maximum	Mean	% of slashed and burnt	Plot size m^2
Western	14	78	44	100	3,300
Central	5	80	40	84	3,860
Eastern	1	73	40	77	3,280
Volta	26	120	62	76	3,750
Mean	11	88	46	84	3,547

percent. At the district levels, 69, 67 and 61 percent, respectively, of the PTPs had be replanted or refilled in Ajumako, Mfantsiman, Jasikan and Akwapim. This situation is the result of using poor quality maize seed bought from Ghana Seed Company (GSC). In some areas, the germination percentage of GSC maize seed was as low as 40 percent. There is an urgent need to obtain seeds of high quality in order to get the full benefit of the technology.

Farmers tend to intercrop where land pressure is high, they have small plots, plant early, and execute fertilizer application and first weeding early. Intercropping was observed among maize PTPs farmers, with cassava being the most usual intercrop (more than 90%), followed by plantain and, to a lesser extent, cowpea or cocoyam. Intercropping was mostly done between rows of maize. An average of 23 percent of PTPs were intercropped, with the Eastern region having the highest number at 33 percent. Intercropping did not adversely affect maize grain yields, especially in PTPs with low plant densities (**Table 7**). Intercropped plots offered a second crop harvest, greater food security, and an additionally source of income.

Fertilizers Application and Weeding Practices--Fertilizer were applied at the rate of 250 kg/ha of 20-20-0 (N+P) as basal dressing and 250 kg of ammonium sulfate

Table 6. PTP Time of Planting, % Replanted Plots, and % Intercropped, Southern Zone

Region	Time of land planting (# days after March 1st.) Minimum	Maximum	Mean	% of replanted plots	% of intercropping
Western	31	80	53	5	20
Central	23	92	60	46	21
Eastern	13	89	51	31	33
Volta	41	138	83	46	16
Mean	27	100	62	32	23

N = 1046

Table 7. Effect in PTPs of Intercropping on Maize Population Density and Performance in Southern Zone

Region	Intercropping Population Density Plants/ha	Grain Yield kg/ha	Without intercropping Population Density Plants/ha	Grain Yield kg/ha
Western				
Central	49,350	3,875	40,400	3,680
Eastern	38,714	3,914	39,142	3,600
Volta	33,667	3,383	34,000	3,950
Mean	40,577	3,724	37,847	3,743

(21% N) as the top-dressing. In 1988, the application of the 20-20-0 to the PTP was executed, on the average, 14 days after planting with the time of application ranging from 3 to 31 days after planting (**Table 8**). (This compares with a mean value for time of N+P application of 21 days after planting in 1987). However, there was not a clear-cut effect on yield from applying the 20-20-0 at planting time. PTP mean yields and population density for NP application at planting were 3,900 kg/ha and 37,500 plants/ha against 3,600 kg/ha and 34,500 plants/ha for later application of the 20-20-0.

The recommended application time for ammonium sulfate was 41 days after planting (**Table 8**). In Western region, where 70 percent of farmers applied 20-20-0 at planting, the time of ammonium sulfate application was also earlier then the recommended six weeks after planting. Weedings coincided more or less with time of fertilization application, except when 20-20-0 was applied at planting. Weeding at time of fertilizer application is of great help for burying fertilizers. Overall, fertilizer application and weeding were executed timely.

Diffusion of the PTP Technology--A PTP is the first step in the field strategy to allow farmers to test recommended technology. It's design involves a one acre plot grown the recommended way next to a one acre plot grown the traditional way. When the technology is tested and accepted, farmers move into the next step by dropping the traditional farmer practices (FP) and adopting the new technologies on Production Plots (PPs). PPs are not of a single type and many deviations were observed. The common denominator of the many variations is the farmer's willingness not to test but to implement the technology by emulating PTPs. The number of PPs therefore is a good indicator of the rate of adoption of the new technology.

Fifty-two percent of the PTP farmers in the Southern Zone in 1987 have gone on to establish a Production Plot. In districts where PTPs were grown previously and had been seen by farmers, 56 percent of the new farmers joining the field program waived the PTP step jumping directly to a PP and dropping their traditional plot entirely; 100 percent of farmers did a PP in Nsawam district and 80 percent in Asuogyaman district (**Table 9**). Farmers skipped the first step and decided to adopt without personally trying the technology. However, they were able to observe PTPs during field days and commu cate

Table 8. Time of Fertilizers Application and Weeding in PTPs in Southern Zone

Region	Compound Fertilizer 20-20-0	Ammonium Sulfate 21-0-0	1st Weeding	2nd Weeding
	# of days after planting			
Western	5	39	25	50
Central	14	42	21	47
Eastern	19	42	17	45
Volta	19	41	22	53

with persons already involved in the project. Combining new districts which embraced SG 2000 for the first time in 1988, 41 percent of the plots growing in the Southern zone in 1988 were PPs. In the Ahanta district, Western region, 90 percent of farmers involved had PP. Information did not flow only within district but beyond districts and regions.

PTPs involve closer supervision from extension officers and invariably yield more than farmers' Production Plots. Grain yield data were corrected to 75 percent shelling percentage and 15 percent moisture content. A mean grain yield of 4.3 t/ha per 39,777 plants/ha was observed for PTPs against 3.8 t/ha for 37,290 plants/ha for PPs. The best maize yields were recorded in the Akropong, Mfantsiman and Asuogyaman districts (**Table 10**). The practice of intercropping was quite similar for PTPs and PPs: 17 percent of the PTPs and 15 percent of the PPs were intercropped. Both the PTPs and the PPs yield much better than the farmer's plot (FP) using the traditional technology. An average of 7 bags/acre (bag = 100 kg) was measured for FPs compared to 17 and 15 bags/acre for PTPs and PPs respectively (**Table 11**).

Table 9. Proportions of PTPs and Production Plots (PPs) in Southern Zone, 1988

District	# of observation	Production Test Plots %	Production Plots %
Ahanta	20	10	90
Denu	49	59	41
Ho	127	61	39
Hohoe	72	51	49
Jasikan	27	100	-
Kpandu	74	46	54
Kwanta	20	60	40
Akropong	58	57	43
Akwapim	13	69	31
Asuogyaman	122	20	80
Manya Krobo	131	66	34
Nsawam	25	-	100
W/Aklm	10	70	30
Yilo Krobo	74	43	57
Cape Coast	13	68	32
Ajumako	48	39	61
Mfanstiman	12	75	25
Swedru	47	40	60
Winneba/Apam	110	28	72

So far, deviation from the recommended PTP practices on the farmer's Production Plot has not affected yields significantly. Only the Cape Coast district recorded a PP mean yield (1.84 t/ha) that was only slightly better than the FP mean yield (1.64 t/ha); these data are not conclusive, since they are based on a very few observations.

Summary of Maize Technology Improvements--PTP farmers in the Southern Zone of Ghana have tended to adhere quite closely to the recommended production practices in adopting the new maize technology. Fertilizers applications and weeding were mostly done in time. More farmers are applying the NP compound fertilizer at planting time and shifting the application of ammonium sulfate earlier than the traditional mean of 42 days after planting. Intercropping did not affect maize yield; it even gave an edge because of the monetary value of the second crop. Population density should be increased in order to improve maize yield. First of all seeds of good quality are required to avoid replanting and refilling. Technical officers should emphasize distance within rows in order to

reach optimum population density. Yields obtained were high enough for both types of plots to ensure adequate return of investment. A gross income of 76,800 cedis can be achieved with 16 bags/acre (average of both PTP and PPs) when the minimum guaranteed price of 4,800 cedis/bag is applied. With a cost of 9,200 cedis for the seed and fertilizer inputs, farmers only have to pay the equivalent of two bags of maize to pay their debts.

Table 10. 1988 Mean Grain Yield (kg/ha) of Maize PTPs,Commercial Production Plots (PPs) and Traditional Farmer Plots (FPs) at District Level in Southern Zone

Region	District	Production Test Plots kg/ha	Production Plots kg/ha	Farmers Plots kg/ha
Western	Ahanta	4,640	4,370	1,600
Volta	Denu	3,639	3,056	1,902
	Ho	4,144	4,165	2,411
	Hohoe	4,205	3,734	2,546
	Jasikan	4,489	-	2,593
	Kpandu	3,750	3,864	2,277
	Kwanta	4,196	3,184	2,378
Eastern	Akropong	5,888	3,337	2,138
	Asuogyaman	4,859	5,891	1,850
	Manya Krobo	3,778	3,490	2,325
	Nsawam	-	3,845	-
	W/Akim	3,115	3,179	1,589
	Yilo Krobo	3,845	3,006	1,353
Central	Cape Coast	4,224	1,840	1,643
	Ajumako	4,493	4,891	1,952
	Mfanstsiman	4,906	3,456	1,429
	Swedru	3,941	3,264	1,516
	Winneba/Apam	3,420	2,996	1,844

Table 11. 1988 Mean Yield (kg/ha) of PTPs, PPs, and FPs in Southern Zone

Region	PTP kg/ha	PP kg/ha	FP kg/ha	% increase over FP PTP	PP
Volta	4,070	3,600	2351	73	105
Eastern	4,297	3,791	1851	132	96
Central	4,197	3,289	1677	150	96
Western	4,640	4,370	1600	190	173
Mean	4,301	3,762	1870	130	101
Mean bags/acre	17	15	7	-	-

N = 1,100

Central Zone

The PTP program in the Central Zone began in 1987 and was entirely focused on maize improvement. During 1988, 750 PTPs were distributed across five districts in the Ashanti region, and 750 PTP were distributed across eight districts in Brong Ahafo region. At harvest, three 100 m^2 sample plots were harvested per PTP as well as each FP. Cob weight, grain weight, shelling percentage and harvest moisture data were taken in the field at harvest. Yields were later calculated in t/ha at 15 percent moisture. Following is a summary of these data.

Progress in the Ashanti Region

The region lies mainly in the high rainfall area but merges northwards into the savanna. A variety of agroecological zones are encountered and maize is an important agricultural activity. Rainfall is bimodal and adequate for maize production. The Ashanti region's transitional zone along the northern fringes of the forest zone provides a very suitable ecology for maize production. For this reason, SG 2000 activities were concentrated in the districts lying within this zone. However, on account of widespread maize production activity over the entire region, some PTPs were also established in other districts as well.

Ejura District

Embracing Sekodumasi sub-district which is famous for maize production, Ejura district shares common boundaries with Mampong and Nkoranza districts. The districts thus lies in the heart of maize production in Ghana. Ecologically, Ejura enjoys transitional forest to savanna vegetation. Two crop seasons per year are possible in most of the district on account of the bimodal rainfall pattern. Further north however, the district's ecology changes to the Guinea Savanna, and a unimodal rainfall pattern (and one season per year) becomes more dominant. Because of its locational suitability to maize production, nearly 50 percent of PTP activity in the Ashanti region was undertaken in Enjura district. Results summarized in **Table 12** indicated a range of 1988 PTP yields from 2.84 to 5.10 t/ha, with a mean of 3.97 t/ha. In comparison, traditional Farmer Plot (FP) yields ranged from 2.04 to 3.62 t/ha with a mean of 2.89 t/ha. Overall, the PTPs had a yield advantage of 37 percent more than the FPs. In physical terms, this translated into an impressive 1.08 t/ha of additional grain.

Offinso District

This district extends over a wide agroecological zone. Stretching from high tropical forest providing a wide expanse of forest reserve, the district stretches across the transitional to the Savanna vegetation zone. Traditionally maize production is

Table 12. 1988 Mean Grain Yields of PTPs and FPs in Ejura District and sub-Districts

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
(1)	4.89	3.62	35
(2)	5.10	3.60	42
(3)	3.13	2.04	53
(4)	3.81	2.81	36
(5)	2.84	2.40	18
District Mean	3.97	2.89	37

undertaken in the area bordering on the Ejura district. Recently, maize production has extended into the forest area where crop cultivation is gaining ground. In this district mean PTP yields range from 3.64 to 6.5 t/ha with a mean yield of 5.1 t/ha (**Table 13**). This compared favorably with FP mean yield which ranged from 1.43 to 4.98 t/ha. The FP mean yield was 2.67 t/ha, with the highest yields obtained in the forest areas. The mean yield gain of the PTP over the FP was 91 percent. This represented a mean difference of 2.43 t/ha.

Ejisu-Bosumtwe District

Traditionally very little maize is produced in this district. Food production is limited to the staples which comprise cocoyam, plantain, and cassava. Farming practice is mixed cropping, in which various crops species are haphazardly distributed over the field. Holdings are less than one acre, due to population pressure on the land. Maize production, in the PTP technology is thus a new experience. Results from activity in the district are summarized in **Table 14**. PTP yields in sub-districts averaged between 3.25 to 4.12 t/ha, with the mean for the district of 3.62 t/ha. On the other hand, farmers yields averaged between 1.67 t/ha to 1.86 t/ha, with a mean of 1.77 t/ha. Substantial gains due to PTPs were observed. The mean yield gains of PTPs over the FP in this District ranged between 95 and 122 percent. From the onset most farmers realized the superiority of the package and abandoned their old practices. This move was a clear indication of early confidence in the method which was supported by the results.

Mampong District

The district encompasses the forest zone and merges into the important maize producing areas in Ashanti. It is covered in part with high plateau. The low lying transitional vegetation zone shares boundaries with the maize producing areas of Ejura and Offinso districts. Historically, Mampong district has a long exposure to improved technology over the years. The effect of this is clearly expressed in **Table 14**. Mean PTP yield for the district was 3.63 t/ha while that from the farmers' plots (FPs) was 3.08 t/ha.

Table 13. 1988 Mean Grain Yields for PTPs and FPs in Offinso sub-Districts

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
(1)	4.45	1.43	211
(2)	5.20	2.05	154
(3)	6.41	4.44	44
(4)	4.45	2.11	111
(5)	4.25	2.14	99
(6)	5.92	2.29	159
(7)	6.51	4.98	31
(8)	3.64	1.89	93
District mean	5.10	2.67	91

Table 14. 1988 Mean Grain Yields of PTPs and FPs in Selected Ashanti Districts and Sub-Districts, Central Zone

District	Sub-district	Grain Yield PTP	FP	% increase, PTP over FP
Ejisu	(1)	4.12	1.86	122
	(2)	3.25	1.67	95
	(3)	3.48	-	-
Mampong		3.63	3.08	18
Bekwai		5.03	1.24	306

Bekwai District

The district is ecologically similar to Ejisu. Identical farming methods are followed and very little maize is produced, even so in a mixed cropping system. Mean PTP grain yields averaged 5.03 t/ha in this district compared to a mean yield of 1.24 t/ha in the farmers' plots **Table 14**. The mean yield gain of 306 percent clearly indicates the superiority of the PTP technology. It was observed that PTP yield for the region was 4.3 t/ha.

Progress in Brong Ahafo Region

The Brong Ahafo region lies to the west and north of the Ashanti region. Predominant ecologies include tropical forests in the southern part and transitional zones and Guinea Savanna ecologies to the north.

Nkoranza District

Nkoranza is a leading maize producing district and farmers have long have been exposed to improved production practices. Use of fertilizer and improved varieties is normal to most farmers. Invariably, land preparation is done by tractor. The district lies in the same agroecological zone coinciding with Ejura and Offinso districts. The predominant vegetation is savanna. A substantial share of SG 2000 field program activities in the region were concentrated in this district. Results of activities are summarized by sub-districts in **Table 15**). In spite of the previous exposure to improved technology, farmers had not adopted the full package in the past. This phenomenon provided an opportunity for comparison. PTP yields ranged from 2.5 to 6.95 t/ha with a mean of 4.35 t/ha. In comparison, yield from FPs ranged from 1.58 to 4.63 t/ha. The mean yield advantage of the PTPs over FPs stood at 46 percent.

Wenchi District

The prevailing vegetation type in the district is the savanna, however, substantial high forest vegetation also exist. Maize production is undertaken over the two vegetation types with reclaimed forest reserves gaining in importance. From results summarized in **Table 16** mean yields of PTPs ranged from 2.89 to 5.87 t/ha, with a district mean of 4.35 t/ha. This compared favorably with FP means which were between 1.55 to 4.79 t/ha. The PTPs had a mean yield advantage of 51 percent over the FPs.

Kintampo District

Kintampo district is unique for its geographic endowment. Lying partly in the bimodal rainfall zone, the district produces two maize crops in a

Table 15. 1988 Mean Grain Yields of PTPs and FPs in Nkoranza District, Bong Ahafo Region, Central Zone

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
(1)	3.26	1.58	106
(2)	4.80	3.24	48
(3)	6.95	4.07	71
(4)	5.07	3.95	28
(5)	2.54	1.65	54
(6)	3.96	2.63	51
(7)	4.22	2.40	76
(8)	3.21	3.03	6
(9)	4.63	3.33	39
(10)	3.30	2.75	20
(11)	4.76	3.14	52
(12)	3.86	2.26	71
(13)	6.03	4.63	30
District mean	4.35	2.97	46

year. In the more northern locations, the district has a single rainfall peak, and only one crop season is possible per year. The district shares a common boundary with Nkoranza, Wenchi, and Techiman. Maize production thus plays an important role in the farming programs of the district.

Sub-district mean yields for both the PTPs and FPs are shown in **Table 17**. PTP yield means in the different sub-districts ranged from 3.25 to 4.28 t/ha, with an overall yield mean of 3.57 t/ha for the district. In a similar manner, the range of FP means were from 2.12 to 3.19 t/ha, with the district average being 2.49 t/ha. The superiority of the PTPs over the FPs had a mean gain of 43 percent for the district as a whole.

Techiman District

The Techiman district borders the Wenchi and Kintampo in Brong Ahafo and the Offinso district in Ashanti. Techiman could thus be regarded as the heart of the maize zone in the central zone. Accordingly, maize production is a common agricultural activity in the district. Traditional low-yielding technologies, however, are still dominant in most sub-districts. PTP and FP maize yields are summarized in **Table 18**. The overall district

Table 16. 1988 Mean Grain Yield of PTPs and FPs in Wenchi District, Central Zone

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
(1)	5.87	4.79	23
(2)	5.79	2.85	103
(3)	4.83	3.28	112
(4)	3.89	2.96	31
(5)	4.43	2.92	52
(6)	3.12	2.30	36
(7)	4.89	3.16	55
(8)	3.75	2.14	75
(9)	2.89	1.55	86
(10)	3.99	2.97	34
District mean	4.35	2.89	51

Table 17. 1988 Mean Grain Yields of PTPs and FPs in Kintampo District, Central Zone

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
(1)	3.29	2.34	41
(2)	3.55	2.12	67
(3)	3.25	2.63	24
(4)	4.28	2.16	98
(5)	3.46	3.19	8
District mean	3.57	2.49	43

Table 18. 1988 Mean Grain Yields of PTPs and FPs in Techiman District, Central Zone

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
(1)	2.49	1.79	39
(2)	4.55	2.09	118
(3)	2.42	1.47	65
(4)	4.38	2.99	46
(5)	3.21	1.71	88
(6)	5.01	2.04	146
(7)	4.02	2.13	89
(8)	3.99	2.06	94
(9)	4.53	4.02	13
(10)	4.70	2.93	60
(11)	4.64	2.01	131
(12)	3.11	2.39	30
(13)	2.80	1.73	62
District mean	3.83	2.26	69

mean for the maize PTPs was 3.83 t/ha, with sub-district PTP mean yields ranging from 2.8 to 5.01 t/ha. Sub-district mean yields for the FPs ranged from 1.47 to 4.02 t/ha, with an overall district mean of 2.26 t/ha. Yield advantage of PTP over the FP had a mean gain of 69 percent. The yield efficiency of the farmers' plots ranged from 42 to 88 percent, with an overall mean of 62 percent.

Sunyani, Berekum, Domaa and Goaso Districts

These four districts of Brong Ahafo lie on the fringe of the maize zone and are marginal for maize production. The vegetation is largely high rainforest. Peasant agriculture consists mainly of root crops and plantain production. With decline in the cocoa industry resulting from bush fires and disease, maize has been making inroads into the food production scene. The need for introduction of correct agronomic practice is therefore desirable.

Maize PTP and FP yields are summarized in **Table 19**. Mean PTP yields in Dormaa district ranged from 3.53 to 5.01 t/ha and mean yields in farmers plots ranged from 1.69 to 3.53 t/ha. Yields obtained in Sunyani district for the PTP were around 4 t/ha while FP yields were close to 3 t/ha. Mean PTP yields from Goaso were close to 6 t/ha, while FP yields averaged 2.89 t/ha, giving an advantage of 105 percent in favor of the PTPs. With regard to the Berekum district, average PTP yields approached 4 t/ha compared with a 2.36 t/ha mean yield for the FPs.

Discussion

Under favorable weather and soil conditions, high yields were of common occurrence. This happened mostly in the rainforest areas. This experience has raised the question of the need to review fertilizer recommendation for specific production regions. From this work, it appears current fertilizer recommendations tended to favor certain conditions. While the highest yields were obtained from the forest areas, lowest yields were invariably obtained from the savannas. However, other considerations also affected the results. Extra-ordinarily high per cent gains resulted when attention was shifted from FPs in favor of PTPs. This observation prevailed throughout the two regions as farmers realized the futility of their former methods.

Early adoption of the PTP technology was apparent. High FP yields resulted from early adoption. Most farmers planted improved variety along the lines recommended. This yields therefore competed favorably with the PTP. Indeed, some FPs out-yielded PTPs. This effect was indicated as negative per cent gains. Even though these were few and isolated it was an

Table 19. Summary of 1988 Mean Grain Yields of PTPs and FPs in Brong Ahafo Region, Central Zone

District	Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
Dormaa	(1)	4.81	3.53	36
	(2)	5.01	2.54	97
	(3)	3.53	1.78	98
	(4)	4.42	2.26	96
	(5)	3.92	1.69	132
	(6)	4.52	3.41	133
Sunyani	(1)	4.28	3.68	16
	(2)	4.03	2.27	78
Goaso		5.93	2.89	105
Berekum		3.96	2.36	68

indication of confidence in the technology. It also revealed the possibility of still higher yields under more ideal conditions. High relative FP efficiencies gave added support to this assertion.

PTP and FP district mean yields in Brong Ahafo are presented in **Table 20** and **Figure 2.** PTP mean yields settled around 4 t/ha while FP yields were about 3 t/ha. Across districts, PTPs registered yield gains from 43 to 87 percent, with a mean yield gain of 59 percent. In the Ashanti region, the yield superiority of the PTP technology over the FP is even more compelling **(Table 21; Figure 3)**. PTP yields in Ashanti were 182 percent higher than FP yields.

Table 20. 1988 District Mean Grain Yields of PTPs and FPs in Brong Ahafo Region, Central Zone

District	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
Wenchi	4.35	2.89	51
Nkoranza	4.35	2.97	46
Kintmpo	3.57	2.49	43
Techiman	3.83	2.26	69
Dormaa	4.51	2.59	74
Goaso	5.39	2.89	87
Sunyani	4.16	2.98	40
Berekum	3.96	2.36	68
Regional mean	**4.27**	**2.68**	**59**

Table 21. 1988 District Mean Yields of PTPs and FPs in Ashanti Region, Central Zone

Sub-district	Grain Yield PTP t/ha	FP t/ha	% increase, PTP over FP
Ejura	3.97	2.89	37
Offinso	5.10	2.67	91
Ejuisu	3.62	1.77	105
Mampong	3.63	3.08	18
Bekwai	5.03	1.24	306
Regional mean	**4.27**	**2.34**	**182**

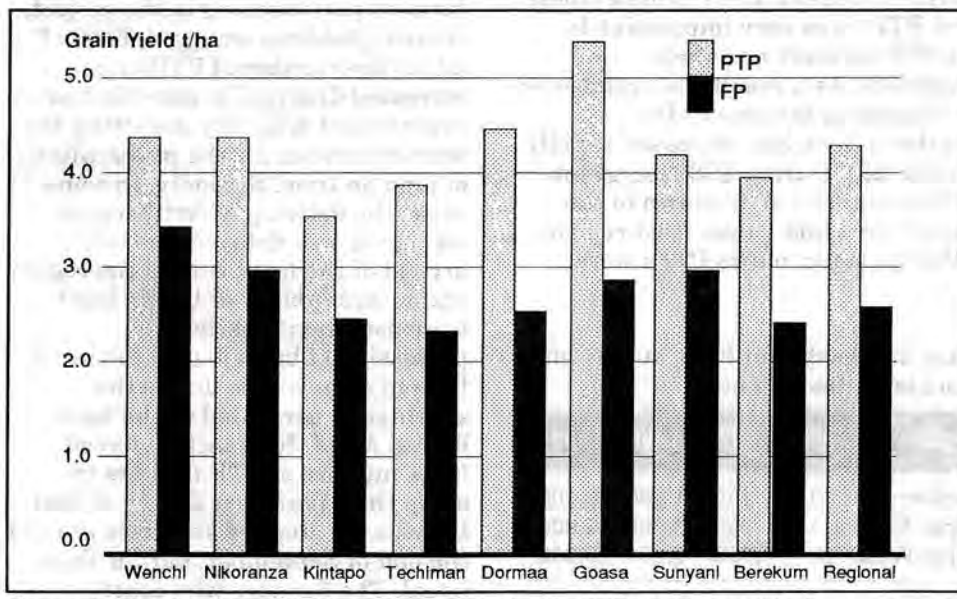


Figure 2. District Mean Yields of Maize Planted in PTPs in Brong Ahafo.

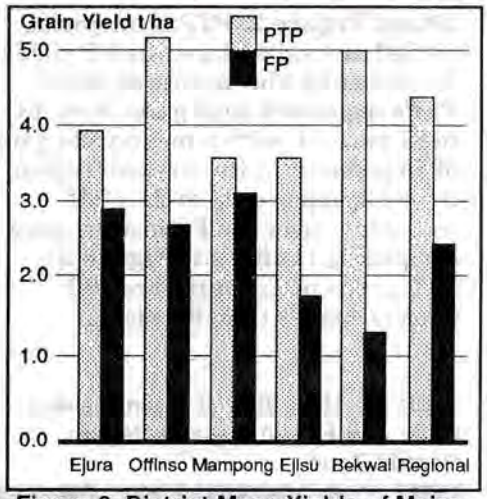


Figure 3. District Mean Yields of Maize Planted in Ashanti.

Northern Zone

The Northern Zone is comprised of three regions: Upper West, Upper East, and Northern. The SG 2000 field program in the Northern Zone was the first to begin. In 1986, there were 20 sorghum PTPs in the Upper West region and 20 maize PTPs in Northern region. The results of these first PTPs was very impressive to the PTP farmers and their neighbors. As a result, the number of participating farmers in the Northern Zone has increased rapidly (**Table 22**). During 1988, sorghum PTPs were primarily grown in the Upper West and Upper East regions, although some maize PTPs were also grown. In the Northern region, maize PTPs were mainly grown although some sorghum PTPs were also planted.

Table 22. Number of PTPs in different years in Northern Zone

Region	1986	1987	1988	1989*
Northern	20	150	1,536	12,200
Upper East	-	220	3,200	15,000
Upper West	20	1,095	7,001	20,000

* Projections

Progress in Upper West Region

In 1986 there were 20 PTPs grown throughout the region, and the yield results of those PTPs were very impressive, with average yields of 2.4 t/ha, as against 0.26 t/ha in the farmers' plot adjacent to PTPs. In 1987, 1,095 farmers joined the Project; the number was much higher than expected. As the weather condition was not as favorable as in 1986, and as there were some farmers who planted the crop later than recommended, the yields of PTPs in 1987 were lower than those in 1986; about 2 t/ha.

1988 Field Program Results

In 1988, 7,001 farmers participated in the PTP program, with approximately 85 percent growing sorghum PTPs and 15 percent maize PTPs. With such a large number of farmers participating in the project, several problems emerged. First of all, as the number of PTPs was increased drastically, some farmers experienced difficulty in getting the tractor services for the preparation of land on time. Secondly, in some areas the delivery of fertilizers to farm gate was delayed due to late arrival of the fertilizers to the region and unavailability of timely local transportation. Lastly, the processing of bank loans took much time in some areas, due to the shortage of personnel in the local banks. All of these factors forced large number of PTP farmers to delay their planting. On top of that, the rainfall stopped suddenly around the end of September, earlier than usual. The farmers who could

manage to plant on time, harvested 2 t/ha or more while the farmers who could not plant on time only obtained yields of about 1 t/ha. As a result, the mean average sorghum PTP yield for the region was 1.52 t/ha, substantially lower than the target yield of 2 t/ha. Still, the average sorghum PTP yield was about three times higher than that of the adjacent farmers' plots, which was 0.48 t/ha.

Two things were noteworthy regarding the farmers' responses to 1988 PTP results. Firstly, even the farmers who could not harvest satisfactory yield from the PTP repaid their loans. By February 1989, the loan recovery rate was 88 percent. Secondly, it seemed that the relatively unsatisfactory experiences of some farmers with PTP, did not erode the faith of the farmers in the recommended technologies. Contrary to the worry that some farmers may tend to stay away from the Project, more than 20,000 farmers have registered to participate in the Project in 1989. When asked about the cause of the unsatisfactory performances of the crop in some PTPs, farmers accepted that the fault was in their implementation of the technology, not the technology itself. Many of them regretted that they could not plant on time. The lessons from the 1988 PTP program were well taken and in 1989, fertilizers were brought into the system ahead of the cropping season, the banks moved faster than last year, and most importantly, farmers rushed to plant on time.

Participation of Ghanaian Banking Institutions

The impressive success of the PTP program in 1986 in the Upper West region was reported to some local banking officials, in hopes that they would be willing to help finance the expansion in the number of PTPs in future years. Their responses were not positive, saying that they had enough burnt fingers with the small-scale farmers, where the loan recoveries had been intolerably low. We responded to their doubts by pointing out the differences between what the bank had done in the past in making small-farmer loans and the SG 2000 technology transfer approach. Previously, banks gave the loans to small-scale farmers without adequate assurance that the money would be used in profitable ways in agriculture. In the SG 2000 approach, the farmers are receiving the loans in the form of the inputs necessary for the implementation of improved crop production technologies and those farmers are under close supervision by the extension officers, to assure that the inputs would be correctly used. So, in the latter system the chances for the farmers to make use of the loans profitably are higher, hence the chances for the farmers to be in a position to be able to repay the loans, are higher than in the former system.

Ghana Cooperative Bank

Our first effort to bring the bank into the scene of PTP Project was neither a great success nor a total failure. Out of few banks we had contacted, the Cooperative Bank responded to our call positively. The bank ventured its first loans to 200 PTP farmers, in Wa District, in 1987. The bank's participation in the PTP program was highly welcomed by both farmers and the officials in the Regional Ministry of Agriculture. There were, however, problems in the bank side; the local branch did have neither enough manpower nor the adequate logistics to service the

large number of farmers in a short period of time. And the circumstances made it inevitable for the extension system to assist the bank in identification of the farmers (borrowers), and in recovery of loans. The first venture of Cooperative Bank in making loans to PTP farmers was very successful; with 100 percent loan recovery rate. In 1988, the Cooperative Bank provided loans to 1,000 PTP farmers, and the loan recovery was again 100 percent, In 1989, the same number of PTP farmers have received the loans from the Ghana Cooperative Bank.

Agricultural Development Bank--Agricultural Development Bank participated in PTP Project from 1988, providing the loans to 2,027 PTP farmers. Being encouraged by the results of 1988, the bank expanded its loan facilities in 1989 to include 4,121 PTP farmers. One commendable point with the Agricultural Development Bank has been that its staff has been more actively involved in farmers (borrowers) identification and loan recovery, not entirely relying upon the extension system.

Ghana Commercial Bank--Bank officials began to show strong interest in the PTP Project after the 1987 harvest. After examining various aspect of the PTP Project, the bank approved the sum of 46 million cedis for loan to PTP farmers in Upper West region, just before the starting of 1988 cropping season. The amount was sufficient to cover 6,000 PTP farmers. Unfortunately, however, loan disbursement was delayed. Since bank officials wished to have all the loan application procedures completed by individual farmers before loan disbursement, there was not enough time. In 1989, however, the bank started processing loan requests earlier than in 1988 and larger amounts of credit will be extended.

Problems in Bank Participation

Our experiences to date in trying to get commercial banks to provide production credit to small-scale farmers in the Upper West region has revealed various institutional problems.

1. Manpower limitations. The local branches of the banks are usually poorly staffed and inadequately equipped. Unless there is a big simplification of the procedures for the disbursement of loans, with present manpower and mobility, servicing large number of farmers will be extremely difficult, if not impossible.

2. Administrative flexibility. Local branches of the bank do not seem to have any flexibility. In view that the transportations and communications are not very effective, local branches managers should be empowered for more than now, if they are to serve the clients more dynamically.

3. Insufficient capital base. The size of fund loanable to the small-scale farmers seems to be not large enough. Money cannot be sufficient in any circumstances. However, if the improvement of the productivity by small-scale farmers is a issue of high priority, then greater availability of credit to small-scale farmers is required.

The block farm concept--The shortage of manpower (too many farmers for an extension officer) and inadequacy of mobility of the extension officers are frequently pointed out as problems that restrict

effectiveness and efficiency in Ghana and in many other developing countries. Making the situation even worse, in Upper West region is the low population density and sparsely scattered farms. Fortunately, there are large pieces of reclaimable land in Upper West region that can be used for crop production. The idea of the "Block Farm" emerged in 1987. The concept was to let the farmers wishing to participate in the Project organize themselves into groups, reclaim the land cooperatively, block the land into one acre block, and test the recommended crop production technologies in each block by a farmer, under the technological guidance of the extension officer. So far, the method has been found useful, increasing the efficiency of extension services; teaching many farmers in one place, encouraging the farmers to share their ideas among themselves, by watching each other's plots, and encouraging the natural emergence of farmer's groups.

Improved Cowpea-Sorghum Sequential Cropping

Cowpeas are an important food crop in Ghana and source of protein. Unfortunately, cowpea production has not increased in Ghana, mainly because more resources (land and labor) have been allocated to cereal crop production. This situation is well reflected by the high price of cowpea in the market; for instance, in June 1989, 100 kg of sorghum was sold at 7,000 cedis while the cowpea at 16,000 cedis.

To help promote greater cowpea production and to assist farmers in these northern savanna areas to increase total farm production, SG 2000 staff suggested to the extension officers to let some PTP farmers test a cowpea-sorghum sequential cropping scheme. In this cropping relay, an early maturing cowpea variety is planted in the PTP before the major season crop, drawing on residual moisture and early rains. As the cowpeas near physiological maturing, the succeeding sorghum crop is planted in alternating rows to the cowpeas. In 1988, six farmers followed the suggestion in the Upper West region and obtained satisfactory yield result--about 200 kg per acre--which gave them sizeable income as a 'bonus'. In 1989, nearly 100 PTP farmers grew the cowpea-sorghum relay and had good yields. Hundreds of farmers visited these PTPs and extension officers estimate that in 1990 many more farmers will adopt this cropping system.

The merits of this cowpea-sorghum system are, 1) the cowpea yields are good because of the residual effect of phosphorus applied to the previous sorghum crop, 2) the early planting has reduced the need to spray cowpeas for the control of insects, 3) in this cropping system, there is no need for plowing of the land for the major season sorghum crop, and 4) it is expected that some quantity of nitrogen available to the next crop is added to soil due to enhanced nitrogen fixation by soil microbes in the presence of cowpea.

Progress in Upper East Region

The Project was started in 1987. The Upper East region is adjacent to Upper West region and has similar climatic conditions and cropping patterns. Naturally, the officials in the Upper East Region Ministry of Agriculture became very eager to replicate what happened in Upper West Region with the SG 2000 Project. With their high enthusiasm

and confidence they ventured to start the Project with 220 PTPs in the first year itself; the Project usually starts with 20 PTPs in the first year, in a new region. In fact, the officials even added 50 more PTPs by arranging the fertilizers for the farmers on loan basis, in cooperation with Farmer Service Company (FASCOM). In a way they were too ambitious, they even did not have enough quantity of improved sorghum seeds. So they had to purchase some sorghum seeds from the PTP farmers in Upper West Region. Some of the farmers did not store the grains properly. Thus, some PTPs suffered from poor germination of seeds. On top of that, in mid-July there were army worm attacks in some PTPs and in mid-August some PTPs were damaged by flooding. In spite of all of these problems, the officials at all levels and the farmers worked hard and achieved commendable results. The average regional sorghum yield in PTP was 1.77 t/ha as against about 0.5 t/ha in the farmers plots adjacent to PTPs; A female PTP farmer from Bolgatanga even received the National Award for high yielding of sorghum.

1988 Field Program Results

Some 3,000 small-scale farmers in the region participated in the PTP program during the year. On top of this, 200 more PTPs were added to allow different organization to participate in the Project. These organizations were, National Mobilization Program (Mobisquad, 50 PTPs), December 31st Women's Movement (85 PTPs) URADEP Farming Systems Research Unit (5 PTPs), Navorongo Secondary School (8 PTPs), SG 2000 Seed Farm (30 PTPs), and mass media group (22 PTPs). The yields of maize and sorghum PTPs and FPs are compared in **Table 23**.

Problems of inadequate seed supplies of improved varieties was again a problem in this region, forcing some PTPs farmers to use local varieties in their plots. Even when local varieties were used, PTP yields were significantly higher than the farmers' plots and the results of PTPs were much better this year than last year. As of January 21, 1989, the loan recovery rate was 88 percent. Some 15,000 farmers registered to participate in the project in 1989. To realize this target, increased amounts of fertilizers and improved seeds were secured before the planting season. In addition, all of the extension staff were supplied with improved means of mobility; either bicycles or motorbikes.

Cooperation between the Extension System and FASCOM--One of the commendable features of the PTP program in the Upper East region has been the close

Table 23. 1988 Average Yields of Maize and Sorghum PTPs in Comparison with Farmers' Plots (FPs) in Upper East Region, Northern Zone

Crops	Yield PTP t/ha	Yield FP t/ha	% Increase, PTP over FP
Maize			
Safita II	2.00	1.25	60
Aburutia	3.50	1.63	115
Dobidi	3.00	1.88	60
Local Maize	1.50	0.75	100
Sorghum			
Framida	2.45	0.60	308
Naga White	3.00	1.25	140
Local Sorghum	1.75	0.50	250

and excellent cooperation between the extension system and FASCOM (cooperation also good with the extension system in Upper West Region). In the Upper West region, in making available the fertilizers to the farmers, the extension service has placed more emphasis on the participation of banks as the source of credits for farmers; in the Upper East region, on the other hand, bank participation has not been very remarkable. However, FASCOM in the Upper East region has made the fertilizers available to some PTP farmers under modified pay schedules: they are lent fertilizers during the cropping season and pay the fertilizer costs after harvest (notably in 1989). The fine cooperation between the extension system and FASCOM has been one of the key factors for the success of the PTP program in Upper East Region. The experiences with the project tell us how crucial it is to bring the technical information and inputs together, if the maximum technological benefit is to be achieved.

Attempts to Manage the Seed Problems--Improved crop variety is one of the key components of the recommended crop production technologies. Unfortunately, in Ghana, the supplies of certified seeds have not been adequate, more so with sorghum. This problem has become more serious as the number of farmers increase rapidly wishing to participate in the PTP project or to adopt the improved crop production technologies on their own. Inadequate availability of certified maize and sorghum seed has forced extension officials to work out alternative means to supply improved seeds to farmers. One of the most practical options has turned out to be the selection of the well-managed PTPs as seed multiplication plots and this option has been implemented in all of three regions of the Northern Zone.

In Upper East region, while the seeds harvested from PTPs are being used the extension system have attempted to improve the quality of seeds in two ways. For maize, they tried to make use of a farmer who has had the experience of producing seed maize for the Grains and Legumes Development Board (GLDB); the farmer was asked to multiply the foundation seed obtained from GLDB, which, in turn, purchased the commercial seed from him. Foundation seed of sorghum was not available, they secured the foundation seed (of the variety Framida) from Burkina Faso, and multiplied it under the supervision of extension staff. These experiences are valuable, showing what can be done at the local level to meet the demand of the seeds of improved varieties under the absence of the certified seeds in the market supplied by the Seed Company (GSC). The attempts to multiply the seeds under the supervision of the extension system may not be ideal for the production of the seeds of very high quality. Still, in the absence of very high quality seeds available in the market, the attempts of extension system to supply reasonable quality seed of improved varieties to farmers is commendable.

Progress in Northern Region

The field program began in the Northern Region in the Damango District in 1986; the first year's maize PTPs (20 of them) were located in one district; Damongo District, in fact, within the Damongo

township. The expansion of the number of PTPs in Damongo in the second year was not as impressive as in Upper West Region, where the number of PTPs was expanded from 20 to 1095 in the second year. In Damongo it grew to 75 in the second year from 20 of the first year. It, however, grew faster in the subsequent years, to 1,080 in 1988 and 6,000 farmers registered to participate in PTP Project in 1989 season. In this region there have been two unique features of special interest the diffusion of the project from one district to other districts, and the rapid farmers' adoption of the recommended technologies.

1988 Field Program Results

In 1988, there were 1,437 maize PTPs (1,080 PTPs in Damongo) and 99 sorghum PTPs in the region. The region experienced unfavorable weather conditions in 1989; prolonged gap of rainfall in the middle of the season and the heavy rains in late August and September, About 200 PTPs were adversely affected specially by the flood. In general, however, crops yields were satisfactory in the PTPs, being much higher than in farmers' plots, as shown in **Table 24**. Like in other regions, the recovery rate of input costs from the farmers have been also high.

The Northern region is one of the largest region in the country, with 10 districts within the region. Thus it has been difficult to cover the entire region at one time, for the in depth training of the extension staff in all of the districts. Instead, we have attempted to concentrate our effort on one district (Damongo) where we first started the project in the region, expecting that the spill-over effect would diffuse to other districts. Of course, the extension officers in the other districts were encouraged to contact the District Agricultural Office in Damongo.

The PTP program in the Northern region expanded in 1987 to include the Bimbilla, Walewale and Gambaga districts (**Table 25**). In

Table 24. 1988 Mean Grain Yields in PTPs and FPs in Northern Region, Northern Zone

District	Maize		Sorghum		% increase, PTP over FP	
	PTP t/ha	FP t/ha	PTP t/ha	FP t/ha	Maize	Sorghum
Damongo	3.95	1.80	-	-	112	-
Tolon	3.40	0.94	-	-	262	-
Bole	3.55	1.56	1.63	0.58	128	181
Walewale	-	-	1.70	0.65	-	162
Gambaga	-	-	1.65	0.67	-	146
Yendi	3.14	1.17	-	-	168	-
Saboba	2.75	1.78	-	-	54	-
Tamale	2.60	0.89	-	-	192	-
Bimbilla	2.10	0.93	-	-	126	-
Zabugugu	2.54	0.97	-	-	162	-
Regional mean	3.04	1.18	1.16	0.63	158	93

1988, the project was started in another six districts, thus covering the whole region. In making this happen, the efforts of the officials in the regional Ministry of Agriculture, offices and the extension officers at the district level have been essential in this expansion.

What is unique in the Northern region has been that the farmers' technology adoption was faster than the growth of the project itself. According to the officials, in 1988, about 6,000 farmers adopted the recommended technologies on their own in Damongo District, while there were only 1,080 PTPs in the district. More surprisingly, in Tamale District, in 1988, about 8,000 farmers adopted the improved crop production, technologies, while the district had only 63 PTPs. Altogether, the officials estimated, while there were only 1,536 PTPs, about 15,900 farmers adopted the improved technologies in the region in 1988. The Deputy Secretary of agriculture in the Upper West also estimated that about 6,000 farmers had adopted the recommended technologies.

By the end of 1987, the SG 2000 project caught on like 'wild fire' expanding rapidly. By 1988, the whole region was engulfed in the program. Farmers requesting participation in 1989 exceeded 35,000.

Table 25. Expansion of PTP Numbers in Northern Region, 1986-1988

	Number of PTPs		
	1986	1987	1988
Damango	20	75	1,080
Bole	-	-	106
Tamale	-	-	63
Tolon	-	-	29
Gambaga	-	25	34
Walewale	-	25	25
Saboba	-	-	6
Yendi	-	-	34
Zabugugu	-	-	24
Bimbilla	-	25	135
Total	**20**	**150**	**1,536**

Program Constraints and Challenges for Future

Among the prime movers of agricultural development (Eicher 1988), it is the political and institutional constraints that are most restricting the diffusion of productivity-enhancing agricultural technologies in Ghana, not the lack of improved technology. The thousands of small-scale farmers who have participated in the PTP program have demonstrated their willingness and ability to improve their grain yields and farm productivity. The primary factors holding back progress are poorly functioning input supply and delivery systems, lack of production credit, and marketing and storage problems that force farmers to sell grain at depressed prices or face the consequences of serious postharvest grain losses.

The production and distribution of quality seed of improved crop varieties is also a major problem in Ghana. The Ghana Seed Corporation (GSC) has ceased to function due to mismanagement and a poor reputation for its products, caused by the frequently poor germination of its seed products (as evidenced in the PTPs grown in southern Ghana in 1988). SG 2000 staff have started to train some PTP farmers in seed multiplication

techniques and intend to promote the establishment of farmer associations and cooperatives to cater for their own seed requirements. In addition, Project staff are also working with government policy makers to develop a new national seed policy that will encourage greater private sector activity in seed production and distribution.

Fertilizer procurement and distribution has also been problematic. Fertilizer frequently arrives late in Ghana and difficulties are experienced in distributing it throughout the country. Until recently, fertilizer supply was exclusively a public sector activity, yet not all regions of Ghana are served by farm input stores such as those operated by FASCOM in the Upper West and East Regions and by Farmers Service Center (FSCs) in some other regions (e.g., Central, Western and Eastern regions). Hopefully, the government of Ghana's plan to privatize fertilizer procurement and distribution will lead to a more responsive input supply system in the future.

Insufficient market demand for maize is becoming a major issue. Repayment of 1988 cost of inputs were retarded due to the significant drop in the price of maize at harvest time. The government was unable to defend its minimum floor price. In addition the government is progressively removing the subsidies from fertilizer. Consequently, the cost of inputs for the PTP has increased from 9,200 cedis/acre to nearly 14000 cedis/acre. In 1988, many farmers were stranded with maize in their cribs or compelled to sell at discounted prices (or on credit) to middlewomen.

SG 2000 is actively seeking ways to reduce the economic disincentives to farmers caused by grain price collapses at harvest time. In collaboration with Technoserve, an inventory credit scheme was initiated in 1988 with two cooperatives in Volta and Central Regions. After harvesting and drying their maize, farmers stored their grain in treated bags and were immediately paid 70 percent of the minimum guaranteed price. Six months later (the maize price was much more favorable), farmers sold their maize, repaid the loan and shared profits following everybody's contribution to the scheme. A loan of 1.5 million cedis was disbursed by SG 2000 for both cooperatives. Gomoa Ojobi farmers made 57 percent profit and Kaira farmers 76 percent benefit over prevailing price at time of storage.

There is an urgent need to strengthen grain marketing and storage systems in Ghana. SG 2000 has initiated some actions in that direction. The storage part of the package consisted only of provision of Actellic 25 (emulsifiable concentrate with 25% pirimiphos-methyl/1). Beginning in 1989, the building of improved narrow cribs will be promoted among PTP farmers. In addition, SG 2000, working with Ghanaian and international research organizations, will evaluate various metallic silos of 1 ton capacity for long-duration storage.

Farmers could be encouraged to grow yellow maize for the poultry industry. The feed compounders in Ghana operate at about 50 percent capacity and 10,000 tons of yellow maize were imported in 1987. Brewers can also absorb a sizeable

volume of maize if they use this grain as the carbohydrate source in beer making. Security stocks of maize could be created in various part of the country. The last and maybe more difficult market development option for surplus Ghanaian grain is to develop export markets. The problem has been that Ghanaian maize is expensive compared to world market price. At current guaranteed domestic price of 5,000 cedis per 100 kg bag, and using FOREX rate of change, Ghanaian maize sells for US$ 143 per ton compared to a world market price of US$ 96 per ton. But with continued productivity improvements, Ghanaian maize costs of production will get closer to world price, thus opening up an export market. For the time being, arrangements with neighboring countries for barter could be successful.

Because of the rapid expansion in the 1989 PTP and PP program--to 85,000 farmers--recovery of input costs may prove to be much more difficult than in previous years. Any substantial future failure to recover these production loan will precipitate the retreat of formal banking institutions from the small-farmer credit program. So, organizing farmers in groups and recovering loans in kind (grain) could help prompt recovery of loan. Support of Ghana Food Distribution Corporation will be needed to store that maize and to sell it later.

Involvement of local institutions becomes more and more needed in order to insure the future of SG 2000 project. Farmers have adopted the technology and have confidence in the system. It is our duty not to disappoint them. SG 2000 however, by building this trust with farmers, has a central position in the whole system. It appears like a buffer between local institutions and farmers. Both sides talk to each other through SG 2000. Rural development is not an overnight affair. Sustainability is a crucial point. As long as farmers themselves do not run their business with full awareness and competence, it will only be a mirage.

References

Eicher, K. 1988. An economic perspective on the Sasakawa-Global 2000 Initiative to Increase Food Production in sub-Saharan Africa. Paper presented at the Sasakawa-Global 2000 Workshop: Reviewing the African Agricultural Projects, Nairobi, March 18, 1988, hosted by the Centre for Applied Studies in International Negotiations (CASIN), Geneva, Switzerland.

Rogers, E.M. 1983. Diffusion of In vation. 3rd edition/OPUSU. The Free Press; a Division of MacMillian Publishing Co. Inc.

The Sasakawa-Global 2000 Agricultural Project in Sudan

*Ignacio Narvaez, Marco Quiñones, and Jose Antonio Valencia**

A Brief Profile of Sudan

Sudan is the largest country in Africa. Its 26 million people occupy an area 10 times greater in size than the United Kingdom. Sudan is often considered to be two entities: the North, which is relatively more advanced, and the South, which is virtually undeveloped. The Arabs, comprise 40 percent of the population and are the largest group. the Negroid Dinkas are next with 20 percent. The remaining 40 percent of the population belong to dozens of tribes and ethnic groups.

The Central and Greater Khartoum regions dominate Sudan's economic, social and political life. The Eastern region, lying between Khartoum and the Ethiopian border, has rich clay soils and traditionally has produced a surplus of grain. The Western region, lying between Khartoum and Chad is poor and frequently food-deficit. The Southern region, populated by various Negro and Nilo-Hamitic tribes, is very underdeveloped and currently racked with civil war. The Northern region, a relatively sparse population is concentrated along the Nile River, with the Nubian and Libyan deserts lying beyond.

About 65 percent of Sudan's people are engaged in agriculture. The top six crops are listed in **Table 1**. Livestock also are very important in the agricultural economy. Sudanese herders tend to more than 35 million goats and sheep, 20 million cattle, and 3 million camels. Cotton accounts for 45 percent of the nation's foreign exchange earnings, gum arabic for 15 percent, and sheep and lambs for 10 percent.

Most Sudanese people still favor large families. A recent survey of household heads indicated that eight children were considered optimum for a family. Population has increased from 11 million in 1960 to over 25 million in 1989. By the year 2000, the UN Population Council estimates that Sudan's population will exceed 32 million, with about one-third living in urban areas, compared to only 10 percent in 1980. By the year 2000, the population of greater Khartoum is expected to exceed 8 million people, compared to 1.8 million in 1980.

* Country Director, Senior Scientist, and Senior Scientist, respectively

Table 1. Production Data on Six Major Crops in Sudan

Crop	1987-88 Area '000 ha	1987-88 Yield t/ha	1987-88 Prod. '000 t	1988-89 Area '000 ha	1988-89 Yield t/ha	1988-89 Prod. '000 t
Cotton	312	1.4	430	321	1.7	530
Sorghum	3,390	.4	1,360	5,884	.8	4,640
Millet	1,096	.2	153	1,500	.2	300
Groundnuts	685	.6	432	614	.9	527
Wheat	144	1.3	181	180	1.4	244
Sugarcane	60	75.0	450[1]	65	77.0	505[1]

[1/] Refined sugar equals roughly 10% of gross tonnage of sugar cane
Source: Department of Agricultural Economics, Sudan Ministry of Agriculture and Natural Resources

The SG 2000 Project

The goal of SG 2000 Project is to assist the Government and farmers of Sudan to improve the productivity of resources devoted to national food production. The Project seeks to transfer improved food crop production technology to the nation's farmers, generally the small-scale producers. SG 2000 vigorously supports the increased use of seed of improved varieties and chemical fertilizers to improve crop productivity in Sudan's irrigated areas. Project leadership and staff are taking an activist role in influencing agricultural policies especially those concerned with fertilizer and seed supply.

SG 2000 staff are working first to improve food crop production in the more favorable environments of Sudan, areas where the greatest productivity gains can be achieved in the near term. At present, the Project is concerned with improving irrigated wheat and sorghum production, where farmers' yields are only one-third what they should be.

Despite the great need of farmers in the marginal rainfed areas, agricultural researchers have not developed, up until now, new technologies to overcome the formidable environmental constraints faced in these arid and semi-arid areas.

SG 2000's Technology Transfer Strategy

The heart of the SG 2000 technology transfer strategy is its field testing and demonstration program. The SG 2000 staff work with extension workers and farmers to test and demonstrate improved technology on tens, then hundreds, then thousands of production test plots (PTPs), which are grown in collaboration with local farmers, to demonstrate and evaluate new production methods, in comparison to the prevailing commercial practices. The food crops selected for the production test plot campaigns are those that are most important to farmers and their sustenance/livelihood.

The technological components recommended in the Project have been developed and/or verified by

the Agricultural Research Corporation (ARC). All the varieties have been released by ARC. (Feedback from the past three years of extensive field testing has also led to some modifications in ARC's official production recommendations, especially with respect to phosphorus fertilizer use, as new information has come to light.)

The Project's production test plots (PTPs) are relatively large in size--one to two hectares--and provide the farmer with a convincing test of the efficacy of the improved technology. The fact that the farmer is directly involved in managing a PTP on his field adds realism and greatly increases the persuasiveness of the test.

In collaboration with extension officers from the Ministry of Agriculture and the Gezira Board, Project staff have worked with Sudanese farmers to plant nearly 5,000 sorghum, wheat and millet production test plots during the first three years of operations (**Table 2**). Most have been sorghum and wheat plots located in the Central region and grown under irrigated conditions. (**Figure 1**). Some millet PTPs were also attemped in the Western region but were discontinued after two years of testing.

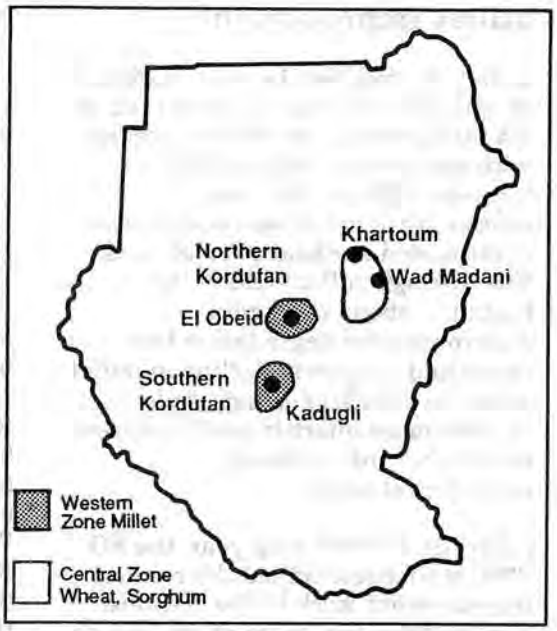


Figure 1. SG 2000 Field Program Operational Zones in Sudan

Through 1989, the cost of the fertilizer, seed, and recommended land preparation methods associated with each production test plot has been financed by the Project. Cooperating farmers have not been required to repay input and land preparation costs. The farmers do assist in planting and caring for the demonstration plots. Farmers interviewed in 1989 indicated that they are willing to pay the full costs of the recommended wheat and sorghum production practices; their major problem is finding where to buy the recommended fertilizers and seed.

Table 2. Number of Production Test/ Demonstration Plots[1]

	1986-87	1987-88	1988-89
Sorghum	315	1,405	1,935
Millet	75	215	--
Wheat	40	464	600
Total	430	1,884	2,635

[1] Plot size is approximately 5 feddans (2 ha).

Millet Improvement

Millet is a crop for the most marginal of agricultural areas. It is planted on 1.5 million ha in the Western region with sandy soils and rainfall between 250 and 500 mm per season. National millet consumption is estimated at about 200,000 tons. The average millet yield in the Sudan is about 200 kg/ha. Environmental degradation has cause and long-term decline in millet years, as rainfall declines, soils become more infertile and the desert encroaches into formerly agricultural areas.

After the 1987-88 crop year, the SG 2000 staff discontinued their millet improvement work in the Western region. After two years of conducting millet yield trials, it was concluded that little in the way of improved millet technology had been developed by the research service to extend to farmers. Improved varieties with drought tolerance have not been developed. Low and erratic rainfall also makes millet production very risky and the use of fertilizer generally unwise.

Sorghum Improvement

Sorghum is Sudan's major food crop; about 2 million tons are consumed annually. It is planted on 4 and 6 million hectares annually, on loamy to clayey soils, and under rainfed conditions with 400 mm and 700 mm of moisture per season. Some 325,000 ha of sorghum are also planted in irrigated areas of the Central Region, generally as part of a rotation system in which cotton is the major crop.

National production is highly variable (dependent upon rainfall) and ranges between 1 and 4 million tons. Sorghum production areas are primarily in the Western and Central regions. In 1987, Sudan exported 543,000 tons of sorghum; in 1988, it imported 640,000 tons; in 1989, it will likely export as much as 1.5 million tons.

More than 2 million ha are grown under large-scale mechanized rainfed schemes in the Eastern Region in which the land is owned by the government and farmed by tenants. These projects, first established during the Second World War to overcome food shortages. Some of the tenancies are as large as 8,000 to 10,000 ha. At the onset of the rains, the land is cultivated and the crop sown by tractor-drawn machinery. Fertilizers, herbicides, and insecticides are not used. An army of casual seasonal labor is used for thinning, weeding, and harvesting and threshing. Sorghum yields in such schemes average about 650 kg/ha.

Many problems plague these large-scale mechanized schemes. Farmers have cleared more land than stipulated on their leases, including corridors left for the passage of nomads and their livestock and tree and bush areas assigned as shelter belts. Continuous monoculture of sorghum has led to a serious build-up of weeds. With traditional fields choked with weeds, it has been more profitable to obtain a new lease and clear virgin land. This shifting mechanized agriculture has decimated wildlife, aversely altered the hydrological cycle, and increased erosion and the process of desertification. While much can be

done to improve productivity in these large-scale mechanized areas, the very large tenancies dissuaded SG 2000 from mounting a technology program there.

The sorghum grown in irrigated areas also suffers from many production programs. Low yields--about 1.2 t/ha--are caused by depleted soil fertility, use of non-improved varieties and/or older improved varieties, excessive plant populations, late planting, and water stress due to inadequate irrigations.

During the 1988 season, the Project's sorghum demonstration plots covered approximately 1,220 ha (2,900 feddans) and involved more than 1,000 farmers. The recommended sorghum production package recommends the use of a hybrid variety, Hageen Dura-1, a seeding rate at 7 kg/ha, or approximately 160,000 plant per ha, moderate applications of fertilizer nutrients (88 kg/ha of N; 44 kg/ha of P), more optimum sowing dates, and improved timing of irrigation. The average yield in these irrigated test plots was 3,200 kg/ha, with the top 10 percent of the plots averaging above 5 t/ha and profits increase more than three-fold (**Table 3**).

Although Sudan is currently self-sufficient in sorghum production Hageen Dura-1 can play an important role in helping to achieve self-sufficiency in bread production. In addition to being high yielding, this particular hybrid has unusually good flour/making properties. Recent milling and baking tests conducted by a USDA consulting cereal technologist have determined that Hageen Dura-1 flour can be mixed with bread wheat flour up to 20% for quality bread production. Thus Hageen Dura-1 can help Sudan reduce its dependency on imported wheat grain and flour.

Wheat Improvement

Although not a traditional food in the Sudan, wheat has been grown for many years in Sudan. With the nation's rapid urbanization, however, wheat is quickly becoming a preferred food. The national wheat area is about 200,000 ha, almost all irrigated. Even so, yields are low,

Table 3. Average Sorghum Production Costs: Traditional versus SG 2000 Recommended Technology, 1988 Season

	Traditional Technology	Recommended Technology
Average yield kg/feddan*	550	1,380
kg/ha	1,315	3,280
Gross income, Sp/fd	825	2,070
Average cost, Sp/fd	400	650
Net income, Sp/feddan	425	1,420*

* 1 feddan = .42 ha = 1.04 acres
** 1 US$ = 12 Sudanese Pounds (Sp), March 1989
Source: SG 2000 Project data

generally around 1.3 t/ha. In 1989, the Government expects to import about 600,000 tons of wheat, valued at about US$ 200/ton landed in Khartoum. In recent years, wheat imports have been growing at about 6% per year.

Wheat is grown during the winter months (November-March) in the Sudan--in a cotton-sorghum-wheat rotation--in several irrigated areas. The wheat-growing season is short, and has higher temperatures and lower humidity than typically encountered in wheat-growing areas of the developing world. Among the constraints limiting wheat productivity, the following are the most important:

- Poor seed bed preparation, resulting in poor stands of seedlings
- Inadequate use of fertilizer (quantity and balance of nutrients) to restore and maintain soil fertility
- Poor water resource management of irrigation canals
- Poor timing for many cultural operations, from planting to irrigation to harvesting

During the 1988-89 season, some 500 wheat demonstration plots covering nearly 2,750 feddans were planted in collaboration with farmers and extension workers. Most demonstration plots have been 5 feddans in size and 10-12 cooperating tenant farmers have tended to plant contiguously in large blocks, covering 60 to 70 feddans. The average wheat yield for the 1988-89 demonstration plots was 3,065 kg/ha compared to an average yield in wheat irrigated areas of about 1,500 kg/ha. The recommended wheat technology is well within the crop management capabilities of cooperating farmers; the profit advantages are also quite pronounced (**Table 4**).

Project Impact

SG 2000 Project has had a significant institutional impact in a very short time. Project staff enjoy the respect and strong support of farmers, extension workers, researchers, and public officials with whom they have worked. In December, the Head of State presented the SG 2000 team with the Order of Production and a gold medal in recognition of their contributions to the nation's farmers.

The yields obtained on the sorghum and wheat production test/ demonstration plots have been spectacular--usually two to four times greater that the cooperating farmer's traditional yields. One

Table 4. Average Wheat Production Costs: Traditional versus SG 2000 Recommended Technology

	Traditional Technology	Recommended Technology
Average yield kg/fd*	630	1,290
kg/ha	1,500	3,065
Gross income Sp/fd	1,260	2,580
Average cost Sp/fd	450	700
Net income Sp/fd	810	1,880

* 1 feddan (fd) = .42 ha = 1.04 acres
** 1 US$ = 12 Sudanese Pounds, March 1989
Source: SG 2000 Project data

village leader who cooperates with SG 2000 said at a 1989 farmers' field day, "I have been growing wheat in the Gezira for more that 50 years but I never have seen a yield such as this," adding, "This must be what the wheat grown in Paradise looks like."

In wheat improvement, the SG 2000 team has been instrumental in the diffusion of a new high-yielding wheat variety, Debeira, and improved cultural practices, especially better land preparation plant stand establishment and more balanced fertilizer applications (e.g. the addition of phosphatic fertilizers). The use of 60kg P_2O_5/ha in wheat production has now become an official recommendation of the ARC. With the harvest of this year, seed of Debeira will be available to plant more than 160,000 feddans next year. Sufficient seed of Condor, the other high-yielding variety heavily promoted by the project, should be available to plant 300,000 feddans next year.

In sorghum improvement, the SG 2000 project staff have been at the vanguard of efforts to promote use of the high-yielding hybrid, Hageen Dura-1, developed by ICRISAT in cooperation with the Agricultural Research Corporation (ARC) of Sudan (and using a Texas A &M University line as the female parent). The ARC is ready to recommend the use of 60 kg P_2O_5/ha (in addition to nitrogen) in recommended production package for irrigated sorghum. This modification in ARC's official production recommendations is very important since the Agricultural Bank of Sudan determines its credit policies on the basis of ARC input-use recommendations.

Mr. Izz El Din Omer el Mekki, Managing Director of the enormous Gezira Board irrigation district has great praise for the Global 2000 staff, whom he considers "a different breed of agricultural scientists than I have known before." "They go into the fields," El Mekki said, "and work side-by-side with our farmers, This has been a great motivation to my staff, especially the younger ones." SG 2000 also has the full support of the Agricultural Research Corporation, whose Chairman, Professor Gameel, credits the Project with "providing a critical link in our efforts to reach the farmer with improved technology."

The SG 2000 Project has helped to increase the awareness of Sudan's political leaders of the potential to increase wheat production and to become more self-reliant in food production. "The wheat demonstration program of SG 2000 has made a major breakthrough," said Mr. Kamil Manzoor, Special Advisor to the Minister of Agriculture. "Before you came, we were about to discontinue wheat production in the Gezira, believing that it wasn't a profitable crop. Now, all political parties are convinced of the need to give increased wheat production a priority; the new Government will support the Committee's plan."

Priorities for Agricultural Development in Sudan

Despite the social desirability of helping Sudan's poorest farmers and nomadic herdsmen--such as those in the Western Region--a minimum rainfall pattern is needed to sustain viable agricultural operations. It is unlikely that many of marginal production areas in western Sudan will ever become profitable commercial food and plant fiber production areas; such is the law of comparative advantage.

In recent years, the World Bank and USAID have spent millions of dollars to develop four research stations in the Western Region, located in Darfur and Kordofan provinces, with the main station at El Obeid. The average rainfall at these four experiment stations ranges between 200 mm and 600 mm per year, so low that serious crops failure occur every three or four years. In our view, the environmental constraints in the very dry, hot climates with no access to irrigate are just to formidable to over come with current technologies and knowledge.

Sudan's most productive agricultural lands (still producing far below their potential) are the irrigated areas supplied water from the Nile river and its tributaries. These irrigated lands are generally publicly owned and rented to farmer tenants. The Gezira Board is the largest public irrigation schemes, comprising about 900,000 ha under one management. Other irrigation schemes (public corporations) include White Nile, Blue Nile, and New Halfa.

International water right agreements for the Nile rivers could permit Sudan to irrigate considerably more land, than is now the case. Presently, Sudan's irrigated lands are grossly underutilized. Canal systems are in serious disrepair (silting, heavy weed infestation, seepage, animal damage, and broken auxiliary pumps), and remains a major production constraint. It is estimated that rehabilitation of the major irrigation schemes will cost $30-35 million. In addition, continuing programs of maintenance must be put into place.

Achieving Self-Sufficiency in Wheat Production

By 1992-93, Sudan is expected to have an annual wheat grain demand of 1.2 million tons. (1988-89 wheat production was about 220,000 tons, the highest in a decade.) Sudan has the potential of achieving self-sufficiency in wheat production through a twin-pronged policy: (1) to increase wheat productivity through the adoption of the SG 2000 production recommendations and (2) to produce sufficient sorghum grain with high gluten strength to allow the blending of sorghum flour (up to 20% sorghum) with bread flour for bread making.

A Technical Committee for Wheat Self-Sufficiency was formed in October, 1988, by the Council of State. The Committee's charge was to devise a plan to achieve self-sufficiency in wheat and bread production within four years. It is composed of senior civil servants from the Ministries of Agriculture, Irrigation, Finance, and Commerce and is divided into five sub-

Committees: infrastructure, land preparation, inputs, incentives for agricultural officers, and incentives for farmers. The Committee has presented a comprehensive list of resource requirements to the Council of State to meet new production target of 300,000 ha of wheat (roughly 750,000 feddans) by 1992-93. The Plan call for a doubling in average wheat yields--to 1 t/feddan or 2.4 t/ha--by 1992. The Committee has draw up a list of inputs, machinery, and irrigation rehabilitation needed to achieve this production target (**Table 5**).

At current prices, the cost of importing one million tons of wheat grain and transporting it to Khartoum would equal about US$ 200 million. With the long road distance from Khartoum to Port Sudan, and the poor state of the railroad line between these two cities, it would also be difficult logistically to transport such large volumes of grain. In contrast, only a little over 100,000 tons of fertilizer would have to be imported to produce about one million tons of wheat grain, following SG 2000 recommended technology. Economically, Sudan would have to spend $26 million in foreign exchange annually to produce $200 million worth of wheat in the irrigated areas, located just south of Khartoum, the major flour market area.

Table 5. Key Wheat Production Inputs Required to Plant 750,000 Feddans (300,000 ha) Using SG 2000 Recommended Technology

Input	Product tons[1] '000 t	Cost US$'000
Imported Inputs		
urea	75.0	$14,000
triple superphosphate	37.5	7,500
machinery	-	5,000
Sub-total	112.5	26,000
Locally Produced Inputs		
improved seed	30.0	$13,000
Total	142.5	$39,000

[1] Fertilizer product tons = weight of active fertilizer nutrients plus inert material
Source: SG 2000 Project data

Improving Technology Delivery

Much of what the SG 2000 Project hopes to accomplish is tied to the modernization of the technology delivery system for agriculture, especially the systems for supplying fertilizers, agro-chemicals, improved seed, tractors and implements. At present, most of these organizations are publicly owned.

Seed--Public sector organizations produce and distribute virtually all commercial wheat and sorghum seed in Sudan. The National Seed Administration (NSA) includes a Seed Propagation Department and a Seed Certification Department. In addition, the large public sector agricultural corporations, like the Gezira Board, produce a substantial amount of commercial seed. A UNDP/FAO Grant was provided for 1984-88 to expand network of seed units, support the seed units of the large public sector agricultural corporations, and provide training in

seed technology; a second institutional strengthening Grant is expected for 1989-93.

The National Seed Administration does quite a good job producing and processing seed. Quantities, however, are still too low and little active promotion of new varieties is undertaken. The large corporations, especially the Gezira Board, actually produce much larger quantities of seed to supply to their farmers.

Presently, wheat and hybrid sorghum seed availability is not a major constraint in Sudan. Sufficient seed of the two best wheat varieties is available for planting some 450,000 feddans next year. Problems in hybrid sorghum seed production persist.

Fertilizer--The Ministry of Agriculture receives donations of fertilizer from various governments and international agencies. Fertilizer donations have been made by the Netherlands, Japan, Denmark, Finland, and FAO. Fertilizer commercially bought and imported is channeled through the Agricultural Bank of Sudan (ABS). ABS is expanding the number of fertilizer distribution centers in the irrigated areas, in anticipation of increased fertilizer use in the country.

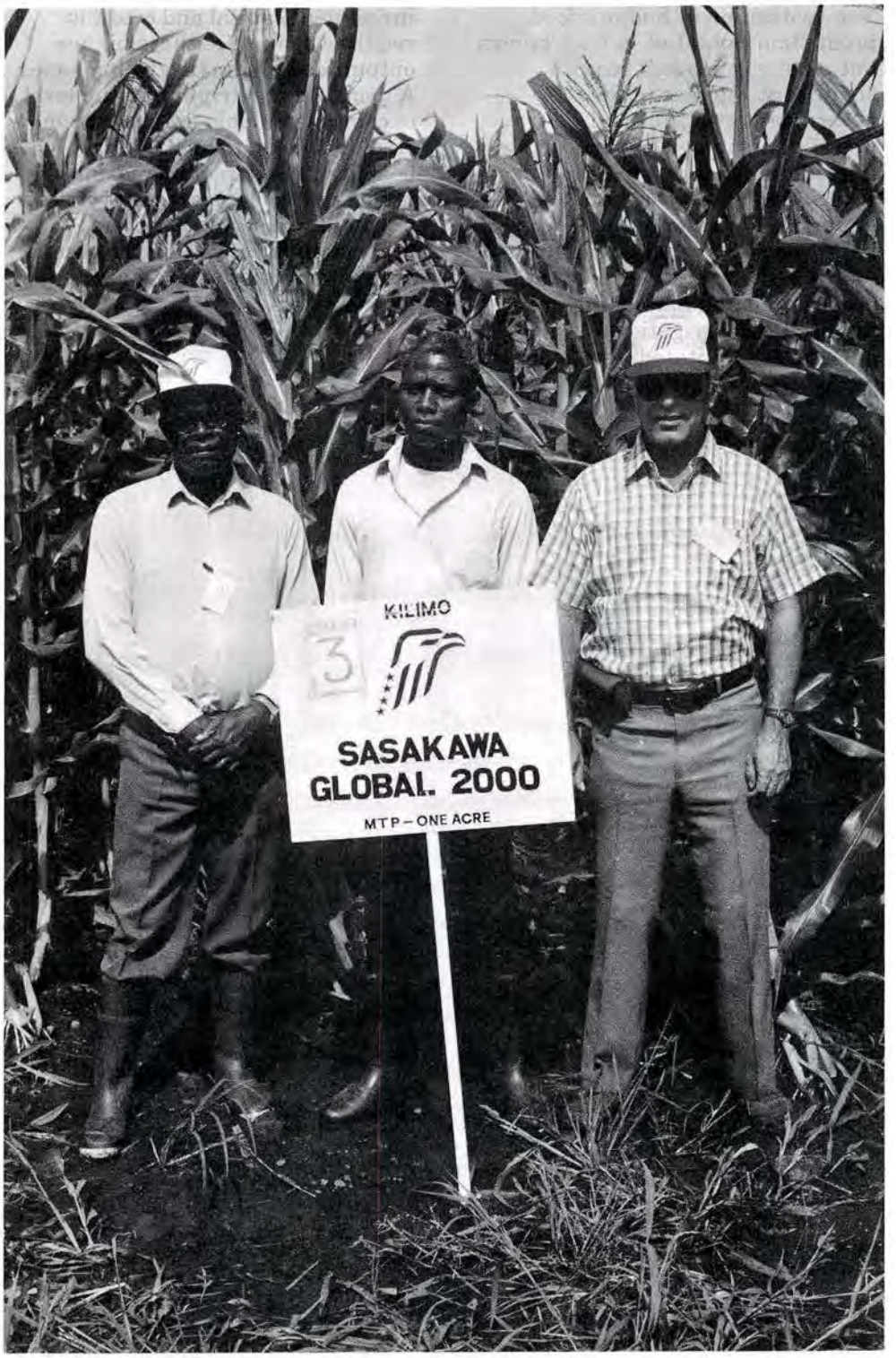
Machinery--There is a need for more machinery to permit more timely crop management operations, especially land preparation and harvesting. In 1988 and 1989, a significant number of wheat fields were harvested so late that 10-20% of the grain was lost to shattering. ABS has ordered some new number of new combine harvesters to handle the expanding national wheat area. Individual farmers and groups are willing to buy tractors and harvesters themselves, if they can get access to credit and the necessary foreign exchange.

Credit--ABS is responsible for providing the nation's farmers with agricultural credit. Preference in granting loans has been given to the cotton crop and to the larger-scale tenant farmers and private land owners. Efforts are now under way to get ABS to expand its credit services for small-scale producers, both for short-term credit to pay for production inputs and services, and for intermediate-term credit to purchase tractors, implements and harvesters, often on a cooperative basis. ABS is expanding its importation of nitrogen and phosphorus fertilizers, agricultural machinery especially combine harvesters, and dredging equipment to clean irrigation canals.

A Green Revolution for Sudan

Technically, Sudan has the potential of tripling average wheat and sorghum yields in irrigated areas through the application of existing agricultural technology. Such productivity gains will increase farmers' incomes, reduce the real cost of food to consumers, and help make the nation self-reliant in basic food production.

The realization of Sudan's food production potential--a long known but elusive goal--will require significant changes in the government's policies and investments in agriculture. Considerably more fertilizer, especially phosphorus, must be imported. Much larger quantities of improved seeds must be produced. Additional machinery for land preparation and harvesting is required. The irrigation systems must be rehabilitated. And more investment capital and credit is required to finance these higher-output food production technologies. A doubling and tripling in the level of capital available for production credit is needed. The potential benefits to Sudan of increasing the productivity of resources devoted to irrigated wheat and sorghum production far outweigh the costs associated with the improved technologies.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Sasakawa-Global 2000 Agricultural Project in Tanzania

*Marco Quiñones, Abu Michael Foster, and N.P. Sicilima**

The Sasakawa-Global 2000 Agricultural Project (SG 2000) in Tanzania was launched in early 1989, in collaboration with the government of Tanzania. Its purpose is to assist the Ministry of Agriculture to deliver improved food crops technology to hundreds of thousands small-scale farmers who have been largely bypassed in past efforts to modernize their production systems. The project has two principal objectives: (1) to mount a large-scale field testing program to demonstrate improved food crop technology and to train national extension personnel to carry on the program and (2) to work simultaneously with national policy makers and international development assistance agency officials to design and implement more effective development programs and policies required to support and sustain the higher-yielding, science-based food production systems.

Profile of Agriculture in Tanzania

Roughly 85% of Tanzania's population live in rural areas and are principally engaged in agriculture. Since independence in 1961, Tanzania has been struggling to find a formula for agricultural exploitation which best suits the country's needs and heritage [1/]. "Village farming" is by far the dominant mode of production, with this category including both individual small-scale farms and the block and communal farms. In general, yields are very low in village food production systems. Farmers rely largely on hand labor and tools and purchase few inputs, such as improved seed or fertilizer.

Tanzania also has some large-scale commercial farming operations. These are mostly medium and large-scale farms owned by private individuals--foreigners or nationals--which are involved in the production of export crops such as coffee, sisal, tea, tobacco, etc. The government also operates some large state farms--mainly used for seed production--and there are als some jointly owned public/private agricultural enterprises, usually involving the Tanzanian government and foreign partners.

Maize is the most important food crop in Tanzania. It is grown on nearly on two million hectares and is produced by most of the nation's

* SG 2000 Project Country Director, Senior Scientist, and National Counterpart, respectively.

farmers. Largely because of area expansions over the last 25 years (1961-65 to 1985-88), maize production has grown at an annual rate of 2.7 percent compared to the national population growth of over 3.5 percent per annum.

Sorghum is grown on 850,000 ha and is the second-most important cereal grain in Tanzania. National yields are low, ranging between 600 and 800 kg/ha. Rice is the third most important crop, with 350,000 ha, followed by millet, with 300,000 ha.

Maize Production Constraints in Tanzania

Maize is grown throughout most of the country, although the most important production areas are located in the Southern Highlands comprising the regions of Iringa, Mbeya, Ruvuma, and Rukwa; and in the Northern Highlands, particularly in the Arusha and Kilimanjaro regions. Ecologically, most maize is grown in the mid-altitude (1000-1500 m) elevations and the highlands (above 1500 m). The highest maize yields are recorded in the highlands where growing seasons are long and the rainfall is generally adequate. A substantial amount of maize is also grown in lowland tropical environments, located mainly in coastal areas along the Indian Ocean and adjacent interior areas; yields here are especially low and the crop is subject to many biotic and abiotic stresses.

A range of biological, economic, social and political factors affect the productivity of maize cultivation in Tanzania. These factors act in combination to constrain the ability of rural peasants to absorb and utilize more productive crop production strategies and their resultant technologies on a wider scale[2/]. The result is that farmers, especially small-scale producers--operate far below their productive potential, with crop yields often only one-quarter to one-third of what they could or should be.

Biological Constraints--Rainfall in the lowland and coastal is often inadequate for reliable maize production.In the low rainfall zone, drought often seriously affects maize yields. Maize diseases and insects can also cause serious economic losses, especially in the highlands and mid-altitude zones. Several leaf blights, stalk and ear rots, and maize streak virus are most serious diseases and several species of stem borer are the most serious insect pests.

Lack of Appropriate Technical Package--Most of the maize genotypes grown in the highlands, whether they be hybrids or open-pollinated varieties, are extremely tall (over 3 m height). When plant population or fertilizer dosages are increased they tend to lodge. Peasant farmers also are yet to learn the importance of timely weeding, particularly when fertilizers and optimum plant population are used. Small-scale farmers are aware that much greater yields are possible but do not possess a full grasp of all of the technological components which must be managed to optimize yield potential and investments in additional inputs, labor, and other services.

Inadequate and Untimely Supply of Inputs--Seeds of the best varieties, fertilizers and agrochemicals are often in short

supply in Tanzania or arrive too late to be used profitably. Approximately 20 percent of the total maize area is planted improved open-pollinated varieties and 5 percent to hybrids; the remaining 75 percent of the maize area is planted to traditional seeds. Some of the hybrid maize seed sold in the country is either produced in Kenya or Malawi; the rest is produced locally. Due to scarcity of hard currency, only a fraction of the total demand for hybrids is covered. Farmers will eagerly accept hybrid seed, if it is ecologically adapted and available at the right time, and if they can afford to pay for this higher-priced seed along with the accompanying fertilizer needed to maximize productive potential.

Fertilizer use in Tanzania is still quite low. The FAO estimated that in 1985-87, only about 6 kg/ha of total fertilizer nutrients were applied per hectare of arable cropland. The FAO fertilizer program which has been going on for almost 10 years have created a good level of awareness amongst farmers about the beneficial effect of fertilizer use and many farmers do apply both N and P fertilizers to maize. The problem is that fertilizers are not always available at village level and/ or peasant farmers do not always have the cash or credit to buy them.

Inadequate Extension Services--The Tanzanian government employs approximately 6,000 extension agents; nearly 4,000 are responsible for providing technical assistance to farmers in improved crop production; the remaining 2,000 are engaged in livestock and community development-related activities. In spite of the seemingly high number of extension officers by African standards, their number is still low for servicing the more than 8,000 villages scattered throughout the country. Moreover, extension officers operate under many organizational and budgetary constraints that have kept it from achieving significant impacts in the modernization of national food crop production systems.

Most extension agents are certificate diploma graduates from an intermediate-level technical agricultural schools. Continuing on-the-job training and education are especially important to these agents to keep them technically current with new research results. But because of serious operational budget constraints, the extension service does not provide regular technical on-the-job training to its field officers. The lack of mobility for extension agents is another constraint in serving the farm community. Most agents reside in the villages they carry on their work on foot. Often, the provision of a simple bicycle is all that is necessary to provide the essential mobility needed to serve farmer clients.

Although farmer demonstration plots have been regularly established by the extension service in the past, these demonstration often have complicated designs illustrating too many production options. Further, the typical demonstration plot in the past was too small in area to serve as a convincing test for the farmer of the yield potential of the recommended technology.

Last but not least are the poor institutional linkages between research and extension services, and other production organizations

concerned with input supply, agricultural credit, and grain marketing and storage. The technology transfer links from the research service are tenuous at best, and the feedback links from extension to the research service are almost non-existence. This lack of integration has reduced the effectiveness of research and production organizations alike.

Lack of Rural Credit for Small-Scale Farmers--Lack of access to cash or to credit has been an important constraint for small-scale farmers in their efforts to modernize production. The dissemination of improved production technologies is clearly accelerated where production credit facilities are extended to small-scale farmers. The challenge is to find cost-effective ways to extend and collect relatively small loans to hundreds of thousands of farmers. In the past, the high transaction costs associated with extending and collecting many small production loans to small-scale farmers, poor technical supervision and management of farmers receiving credit, and inadequate capital formation (savings) in rural areas have made it difficult to develop and sustain viable small-farmer credit programs.

Inadequate Marketing Systems--Tanzania has experienced several changes in her marketing institutions over the last 20 years. Presently, parastatal cooperative unions have been responsible for grain purchases from village farming units for resale to the National Milling Corporation (NMC) and other institutions. These cooperative unions are required to establish marketing facilities, such as transport, handling equipment, storage, etc., and are supposed to have access to the financial resources for purchasing the crop harvest at village level. However, due to shortages in cash resources and poor feeder roads, many villages are not able to market their produce on a timely basis. Postharvest grain losses are high, mainly caused by grain rots, stored-grain insect pests, and vermins. Improved grain storage structures and preservations methods are needed to reduce these losses, which can exceed 30 percent of the harvested grain.

The Kilimo-Sasakawa-Global 2000 Agricultural Project

In early 1989, SG 2000 project staff began working with Ministry of Agriculture officials concerned with agricultural extension, research and policy to initiate and manage a dynamic field testing program to diffuse improved maize and sorghum production technologies among the nation's small-scale farmers.

Operational Zones--Three main operational zones have been identified in consultation with government officials. These include the Northern Highlands (with Arusha Region as the base), the Central Plateau (with Dodoma as the base) and the Southern Highlands where Iringa probably will be the center for field operations (map zones, **Figure 1**). In these three main operational areas, improved technologies for maize, sorghum and pearl millet, and for mixed maize-based farming systems, respectively, will receive the major emphasis. As resources permit, and results are achieved, the field testing program will expand to other areas of Tanzania where improved technology exists but awaits transfer to farmers.

Project Coordination--The Sasakawa-Global 2000 program will be guided by a national advisory committee. The committee members will consist of key government officials and heads of institutions related to agriculture. The program will be executed by a Central Management Team (CMT) consisting of the SG 2000 country director, an assistant director, and a national counterpart. At regional level, members of this team will coordinate the program through the Regional Agricultural Development Office (RADO) with the assistance of a Regional Coordination Team (RCT). A full-time field coordinator will be appointed in each region to supervise the report on progress of field operations to the RCT. At district level, the district supervisors will oversee day to day operations and coordinate activities of ward officers as per monthly activity schedules. These activity schedules will be drawn up by field coordinators for each ward officer in consultation with District Agricultural Office (DADO).

Project Methodology--The Kilimo-Sasakawa-Global 2000 Project methodology is focused on a technology transfer process in which information, dissemination and training are mutually reinforced through an enhanced system of linkages between farmers and supporting institutions such as extension services, research, input supplies, and lending institutions (**Figure 2**). This technology transfer methodology embraces some of the elements of the Training and Visits (T&V) system that has been promoted by the World Bank in many countries. A training program has been devised to suit the available resources of the extension services and the circumstances of small-scale farmers. Hands-on training is conducted on farmer's individual fields using one to two acres of the field as a management training plot (MTP). The MTPs are strategically distributed within the community to permit easy access to farmers. Thus, MTPs are contact points where farmers meet periodically. At these meetings extension agents

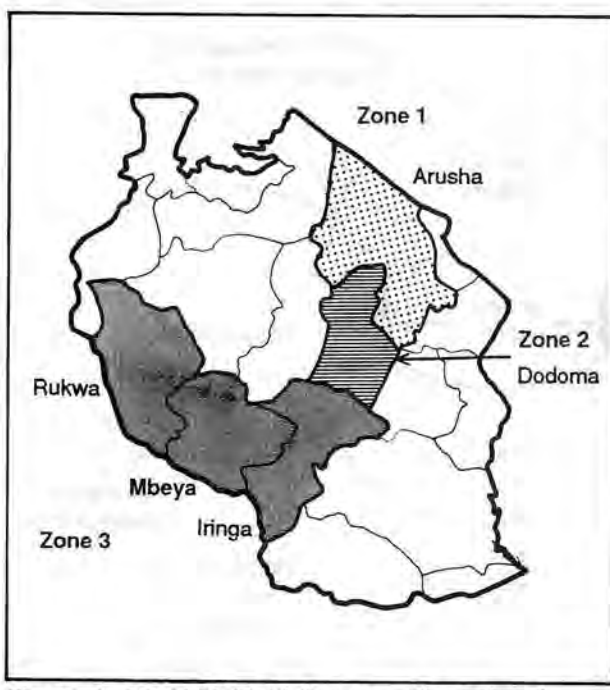


Figure 1. SG 2000 Field Program Operational Zones in Tanzania

and farmers review the performance of the crop, in relation to the different management operations, and received training about the recommended practices.

Inputs required to establish the MTPs are provided through the program to farmers on individual or group basis. The cost of these inputs are recovered from the participating farmer at the end of the season. A proportion of the production loans will be provided by SG 2000 and the remainder from national institutions. Repaid SG 2000 loans will be deposited in national (or regional) revolving funds to help finance future MTPs. Previous participants from the MTP program hopefully will be provided seasonal production credit loans from existing commercial lending institutions. Through the scheme it is hoped that the rate of adoption of the improved production technology will be actively enhanced.

Technical Details of the Production Package--Production packages are formulated and tested on the basis of currently available research information, as such they are oriented to suit particular farmer's circumstances within defined agro-ecological zones. As further research information becomes available, the components of the production package may vary by kind or degree. Presently, the following production technologies are recommended for full-season maize cultivation. (**Table 1**).

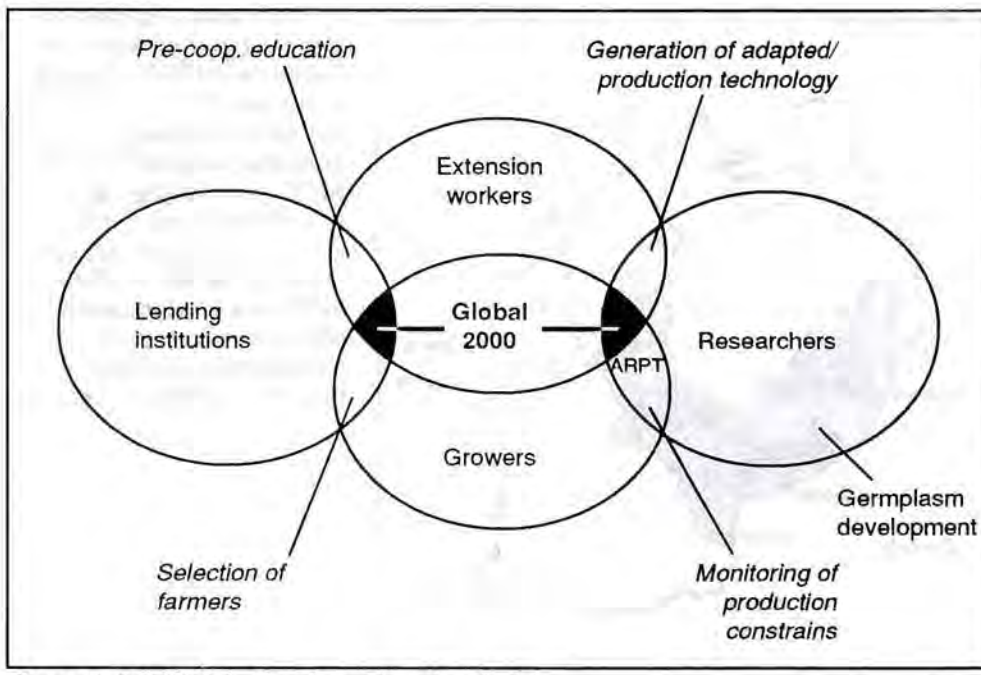


Figure 2. SG 2000 Technology Transfer Model

Field Program Operations--Field program operations are organized around four main stages of crop development: (1) preplanting, (2) top dressing, (3) flowering, and (4) harvesting. MTP-related training activities organized for extension workers and farmers are carried out during each of these periods. Future MTP participants will be recruited from among farmers who actively participate in these training sessions.

Table 1. Recommended Production Package for Maize MTP in Arusha Region (Arusha and Arumeru Districts)

Variety	Seed Rate kg/ha	Time of Planting	N:P Basal Dressing kg/ha	N Top Dressing kg/ha
H-632	20	Late Feb. to early March	30 : 57.5	85
H-511	20	Late Feb. to early March	30 : 57.5	85
Kilima	20	Late Feb. to early March	30 : 57.5	85

Crop Management Recommendations

1) Long-duration varieties should be planted no later than early March.

2) Optimum plant population density should be targeted at 50,000 plants/ha. Using a planting arrangement of 80 cm between rows and 50 cm between hills, with two seeds per hill.

3) Basal fertilizer dressing is applied in a mixture of the full recommended amount of TSP with approximately a third of the recommended amount of N in the form of urea; fertilizer top dressing should be applied at-knee-high stage (8 to 10 leaf stage).

5) First weeding should be carried out at 2-3 weeks after planting; second weeding at 4-6 weeks after planting (Note: second weeding may be combined with top dressing application if weed population density is low).

6) If insect damage exceeds economic threshold value, control measures should be taken. Appropriate insecticide should be applied at recommended dosage and in the context of an integrated pest management approach.

List of Activities for Implementing MTPs:

- Selection of participating farmers within target group.
- Demarcation of strategically placed fields.
- Organization of preplanting field days at onset of first reliable rains at district level by the district supervisor and field coordinator.
- Supervision and training of farmers by ward and village extension officers at village level from planting to knee-high plant stage.
- Organization of district-level field days by the district supervisor and field coordinator at time for top dressing fertilizer application
- Supervision and training of farmers at village level during top dressing fertilizer application.
- Organization of farmers forums at flowering plant stage at district and village level.
- Pre-harvest evaluation of crop performance and demarcation of area to be sampled for yield at harvest.
- Yield estimations on representative fields at harvesting within sample frames (10 rows x 10 m = 80 m^2).
- Result and demonstration field days at harvesting time at ward and village level.
- Remind farmers about repayment of loans at harvesting. At the time of selling the crop the farmer should repay the amount due on the cost of his inputs. The credit should be collected by the ward extension officers and handed to the district supervisor and subsequently handed to the field coordinator.

Scope of Field Testing Program-- The field testing program was initiated in the 1988-1989 season in the Arusha region of the Northern Highlands. A total of 67 Management Training Plots (MTPs) each of one acre in size, were planted during March-April to inaugurate the program in Arusha Region this year. Training activities are already underway and numerous field days have been organized as a training exercise for extension workers and farmers. The field program in the Central Plateau and Southern Highlands will begin in November at the start of the 1989-90 cropping season.

With regard to the loan scheme, discussions have been scheduled with regional managers of the financial lending institutions. The objective is to develop a suitable mechanism for operating a seasonal loan scheme in the 1989-90 cropping season. The Arusha zone of the National Farming Systems Research Group has undertaken a commitment to support the on-farm testing activities associated with refinement of the recommended MTP production packages. Consequently, appropriate support has been provided by SG 2000 to develop a formal framework for mutual collaboration between the two

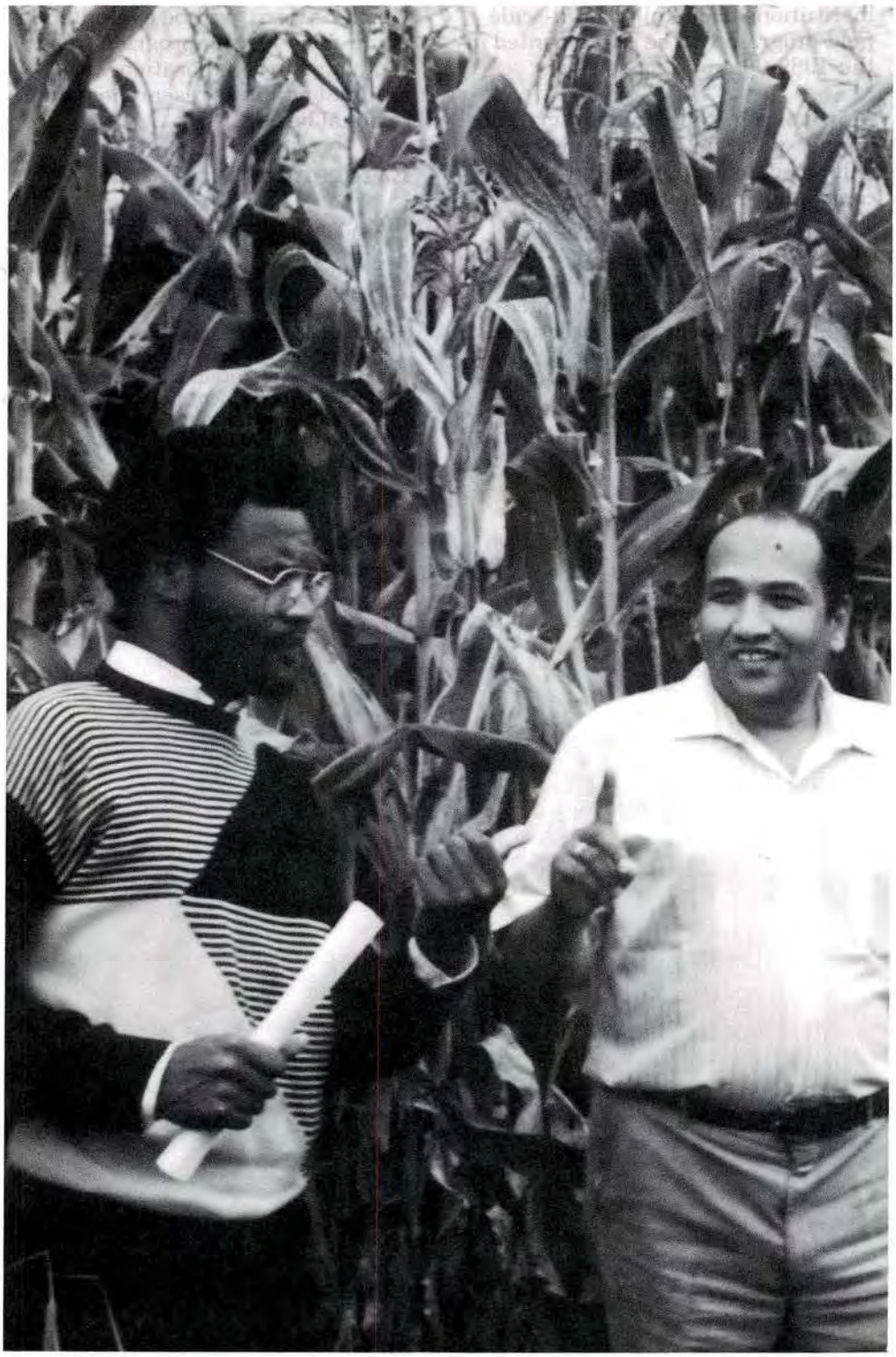
institutions. Hopefully, a full-scale field program will be implemented in the 1989-90 cropping season.

Monitoring Project Impact--The impact of the field testing program will be evaluated through a continuous monitoring process. Through surveys in the farming communities involved, extension and research staff can keep in touch with the performance of recommended varieties and production practices. Feedback from farmers and their yield trends will help researchers and extension officers to make the necessary technological refinements which, in turn, will be evaluated in an on-farm testing program to be conducted in collaboration with national adaptive researchers on a regional basis.

References

Ministry of Agriculture (1983). The Agricultural Policy of Tanzania. pp. 1-35 Printed by The Government Printer. Dar es salaam Tanzania.

Okigbo, B.N. (1984). Improved permanent production system as an alternative to shifting intermittent cultivation, pp. 1-100. In improvement production systems as an alternative to the shifting cultivation. FAO Soils Bulletin No. 53 Rome: FAO.



Global 2000-BCCI Agricultural Project in Zambia

*R.P. Jain, C. Masi, and M.A. Foster**

Agricultural Profile of Zambia

Zambia has great potential for food production. The country has 41 million hectares of arable land available for agriculture, out of which 12 million is cleared (**Figure 1**). Of the cleared land, 4.9 million ha is used for regular cultivation (each year about 2 million ha is cultivated and 2.9 million ha is left fallow). About 7.1 million ha is used for shifting cultivation. The remaining 29.1 million ha of the arable land (70%) is not cultivated. These figures clearly indicate that Zambia has much scope to expand the area under crop production.

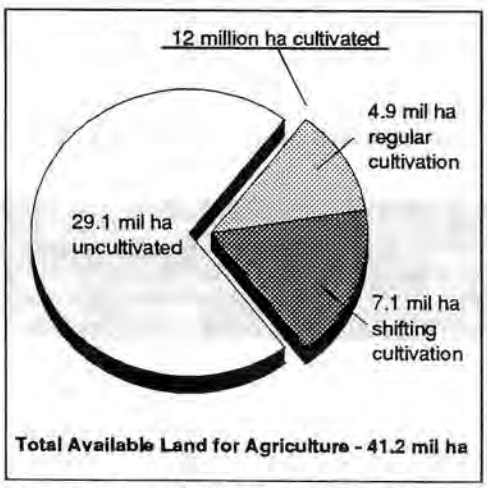


Figure 1. Land Utilization in Zambia

Zambia has a population of about 7 million people and a typically high population growth rate of 3.1 percent per year. Approximately 57 percent of the population live in rural areas and the remainder in urban zones. Small-scale farmers constitute about 85 percent of rural farming community but contribute only 60 percent of Zambia's total food production.

The farming community of Zambia can be divided into four groups; the characteristics of each category are given in **Table 1**. Maize is the staple food for over 80 percent of the population and is grown as the most important cash and subsistence crop. In relatively low rainfall areas where maize can not be grown sorghum is cultivated. The area, production and mean grain yield of maize and sorghum during the last five years is given in **Table 2**.

The major constraints to maize and sorghum production include sub-optimal agronomic management practices, lack of draft power, labor shortages at peak periods of land preparation and weeding, inadequate credit facilities, and shortage of improved seed and fertilizers. Among the diseases of

* Global 2000 Country Director, National Counterpart, and Senior Scientist, respectively.

maize, ear and stalk rots, leaf blight, and streak and mosaic viruses are of the greatest economic importance. Important insect pest include stem borers, cutworms and rootworms, and termites. There is dearth of information on agronomy, production and plant protection of sorghum. The majority of the sorghum farmers use unimproved local varieties which are photosensitive, tall and late maturing with low yield potential.

Table 1. Some Characteristics of Four Main Farmer Categories

Particulars	Traditional	Small-Scale	Institutional/ Emergent	Large-Scale Commercial
Size of farm	up to 5 ha but usually less than 2/ha	2-10 ha	10 - 40 ha	40 ha and over
Source of farm power	Hand	Hand and oxen or hired tractor	Hand, oxen and tractor	Mainly tractor; sometimes oxen
Labor Source	Family; communal; sometimes casual	Family, communal, casual	Family, casual and occasionally permanently hired	Permanent and casual hired labor
Purchase of inputs	None	Ferilizers, seed, ox-drawn equipment	Seed, fertilizers, pesticides, ox-drawn and tractor-drawn equipment	Fertilizers, seed, pesticides, mechanized equipment of all kind

Table 2. Area and Production of Maize and Sorghum in Zambia, 1984-85 to 1988-89

	Maize			Sorghum		
Year	Area ('000) ha	Production '000 t*	Mean Yield kg/ha	Area ('000) ha	Production '000 t*	Mean kg/ha
1984-85	582	1,223	1,928	25	198	792
1985-86	588	1,228	2,092	60	450	750
1986-87	610	1,064	1,744	47	261	555
1987-88	723	1,453	2,009	47	360	695
1988-89	905	1,861	2,056	51	370	714

Source: Statistics Section MACO, May 20, 1989.
* Originally cited in million of 90 kg bags; coverted to metric tons

Global 2000-BCCI Program

The program was established in October 1986, with funding from the Bank of Credit and Commerce International (BCCI) through its local subsidiary, BCC Ltd., and the BCCI Foundation (Zambia) for New and Emerging Sciences and Technologies (NEST). The project's main objective is to increase national food production and agricultural productivity through the transfer of improved new technology to small-scale farmers. A management and coordination unit was formulated to assist in planning and implementation of project activities. The members of the committee were drawn from key sections of the Ministry of Agriculture and Cooperatives (MAC) and BCCI Foundation for NEST.

Summary of the Field Testing Program

The field testing program is the heart of the project's activities. Management Training Plots (MTPs) are used as the central tool to demonstrate improved crop production methods to client farmers and to facilitate training of extension workers and farmers. Each MTP is about one acre in size (0.4 ha) and is managed by the farmer under the supervision of the local extension officer. The technological components demonstrated in MTPs include improved crop genotypes, economic doses of fertilizer and improved crop management. Complementary on-farm adaptive research should in the near future permit better tailored recommendations for specific agro-ecological zones.

In the first year, the program was initiated in three of Zambia's nine provinces in consultation with the Ministry of Agriculture and Cooperatives. One district each was selected in Central and Copperbelt provinces and two districts in Lusaka province. A total of 252 MTPs were established. In the 1987-88 season, field program coverage expanded to include all blocks and camps in Ndola Rural, Mumbwa and Kafue districts and the addition of six new districts in the Copperbelt province, namely Chingola, Kalulushi, Kitwe, Luanshya, Mufulira and Ndola Urban. The field program was also extended to Gwembe North district in the Southern province, which is a main sorghum-growing area. A total of 1,117 MTPs were planted during this second year of field testing. The field program was further expanded in 1988-89 cropping season to include farmers in the Mkushi and Serenje districts in the Central province, the Chililabombwe district in the Copperbelt province, and all the blocks and camps of Lusaka Rural East district of Lusaka province.

The 1989 coverage of the MTP program is shown in **Figure 2**. MTP areas were frequently visited by the Global 2000 staff and contacts were established with the Provincial Agricultural Officers (PAOs) at the provincial level. District Agricultural Officers, in consultation with the PAOs nominated district Global 2000 coordinators to oversee the field testing project; these individuals were provided a 4-wheel drive automobile to oversee field operations in their area of responsibility. Motorcycles and bicycles were also made available to extension workers at block and camp level when considered necessary for

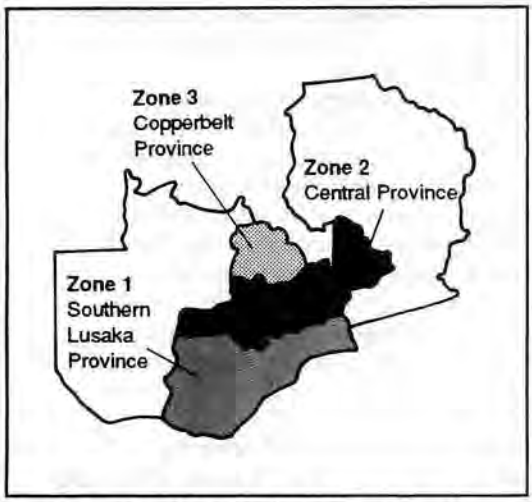


Figure 2. Global 2000 Operational Zones in Zambia

the implementation of the field program.In order for the extension staff to fully understand the crop production package, pre-planting, mid-season and pre-harvest training courses were organized.

Table 3. Performance of Maize and Sorghum MTP's in 1986-87 Cropping Season

	Mean Grain Yield		%increase over
District	kg/ha	District Mean	distrtict means
Maize			
Ndola Rural	6079	3618	68
Mumbwa	4801	1133	324
Lusaka Rural	4503	1204	274
Sorghum			
Ndola Rural	1212	550	121
Mumbwa	2220	774	187
Lusaka Rural	367	300	22

Modification of Crop Production Packages--With each successive year of field testing, the recommended maize and sorghum production packages have been modified and updated, in consultation with national scientists. The most significant refinement for maize production was planting at a spacing of 80 cm between rows and 50 cm within rows (2 seeds/hill). This has facilitated the hand hoe farmers to alleviate labor constraint at the time of planting, fertilizer application and weeding operations. The new varieties/hybrids of sorghum were introduced to the farmers and these have much higher yield potential than the local genotypes. They perform reasonably well even under adverse growing conditions.

MTP Yield Performance--Grain yield results of maize and sorghum MTPs during 1986-87 and 1987-88 cropping seasons are presented in **Tables 3** and **4,** respectively. A perusal of the two years results show that an increase of two to four times in production of maize and sorghum crops can be achieved by the small-

Table 4. Performance of Maize and Sorghum MTPs in 1987-88 Cropping Season

	Mean Grain Yield, kg/ha		
Province/ District	MTPs	Small-Scale farmers	% increase over farmers
Maize			
Copperbelt	4432	2446	81
Central	4856	2157	125
Lusaka	4055	1855	119
Sorghum			
Mumbwa	1723	497	247
Lusaka Rural	1378	599	130
Gwembe North	859	74	1161

scale farmers through use of improved seed, optimum doses of fertilizer and timely field operations. The management training plots in all the operational zones have acted as catalysts for improved productivity and diffusion of technology among small-scale farmers.

1988-89 MTP Program Coverage--A total of 1,410 management training plots (MTPs) of maize and sorghum were established in four provinces in 1988-89 (**Table 5**). The loan scheme was introduced in four district of Copperbelt, Lusaka and Central provinces. The climatic conditions during the 1988-89 season generally

Table 5. Field Program for 1988-89 Cropping Season

Province by Districts	MTP Program Maize	Sorghum	Millet	Total	BCCI Loan Maize
Copperbelt Province					
Urban Districts	500	-	-	-	-
Ndola Rural West	60	-	-	560	-
Ndola Rural	-	-	-	-	1092
Total production units in progress					**2744**
Central Province					
Mumbwa	-	50	-	-	776
Serenje	300	-	-	-	-
Mkushi	190	-	-	-	-
					540
Total production units in progress					**2092**
Lusaka Province					
Lusaka Rural East	110	10	-	-	-
Chalimbana- Kampekete	10	-	-	-	140
Kafue (Chiawa)	-	100	-	-	-
Kafue Rural West	-	-	-	230	256
Total production units in progress					950
Southern Province					
Gwembe North	-	55	25	80	-
Total production units in progress					**80**
Grand Total MTPs	915	220	25	1410	2228
Grand Total production units in progress = 5866					

were favorable for the maize and sorghum crops. The grain yield as obtained by the farmers from the production plots was very encouraging (**Table 6**). The mean grain yield of maize in the project area ranged from 4.2 to 5.9 t/ha which was substantially higher than the small-scale farmers' plots. It is encouraging to note that adopting farmers were able to get high yields. The loan farmers have obtained comparable yields to MTPs as the production packages for the MTPs and production plots were identical. The results indicate that farmers have used the new technology in a right manner.

Similarly, the performance of sorghum MTPs was excellent. The grain yield was highest in Gwembe North (2,060 kg/ha) which was four times more than the traditional farmers. The farmers of Gwembe North were very enthusiastic in the field days and have requested the assistance from Global 2000/Ministry

Table 6. Comparision of Maize and Sorghum Grain Yields in the 1988-89 Cropping Season

District	MTP	Loan	AFP	TFP	% Increase over TFP
		Mean Grain Yield kg/ha			
Maize					
Lusaka Province					
Lusaka R.E.	4,663	4,957	4,600	3,551	31.3
Kafue		4,225	3,364	2,222	90.1*
Central Province					
Mumbwa		5,866	4,061	1,820	222.3*
Mkushi**	4,735		-	2,700+	75.4
Serenje**	4,538		-	3,150+	44.1
Copperbelt Province					
Ndola Rural		5,313	3,639	2,227	138.6*
Copperbelt U.	4,579		4,375	1,884	143.0
Sorghum					
Lusaka Province					
Lusaka R.E.	1,190			700	70.0
Central Province					
Mumbwa	1,505			720	109.0
Southern Province					
Gwembe North	2,060			360	472.2

MTP=Management Training Plots; AFP=Adopting Farmers' Plots; TFP = Traditional Farmers' Plots
* Comparison based on the production plots
** New operational areas
\+ Obtained from the final forecast data for 1988-89, Planning Division, MAC.

of Agriculture and Cooperatives for seed of new sorghum genotypes and fertilizer to adopt the new technology. Accordingly plans are underway to cover a larger number of farmers in the area.

Establishing Production Credit Loan Scheme--One significant development that has happened in 1988-89 cropping season was the introduction of a loan scheme with the assistance of BCCI. The scheme is novel in its own way and is necessary in order to increase the effectiveness of the project and to enhance the adoption rate of the technology. The extension officers of the department of agriculture are involved in each stage of farmer selection and bank officers participate through visiting farmers in their respective camps to complete the agreement forms. After which requisition slips are given to the farmers for the collection of inputs from the nearest cooperative depots. Since the bank has already signed the agreements with the respective Provincial Cooperative Unions and pays in advance for the inputs to the unions, the participating farmers can collect seed and fertilizer well in time before the start of planting time. About 2,228 farmers were covered by the loan scheme this year. The stop orders signed between the farmers and the bank will facilitate the repayment of the loan money by farmers to the bank through the Cooperative unions. The loan scheme has been appreciated by Government of Zambia and farmers and has the potential to become an

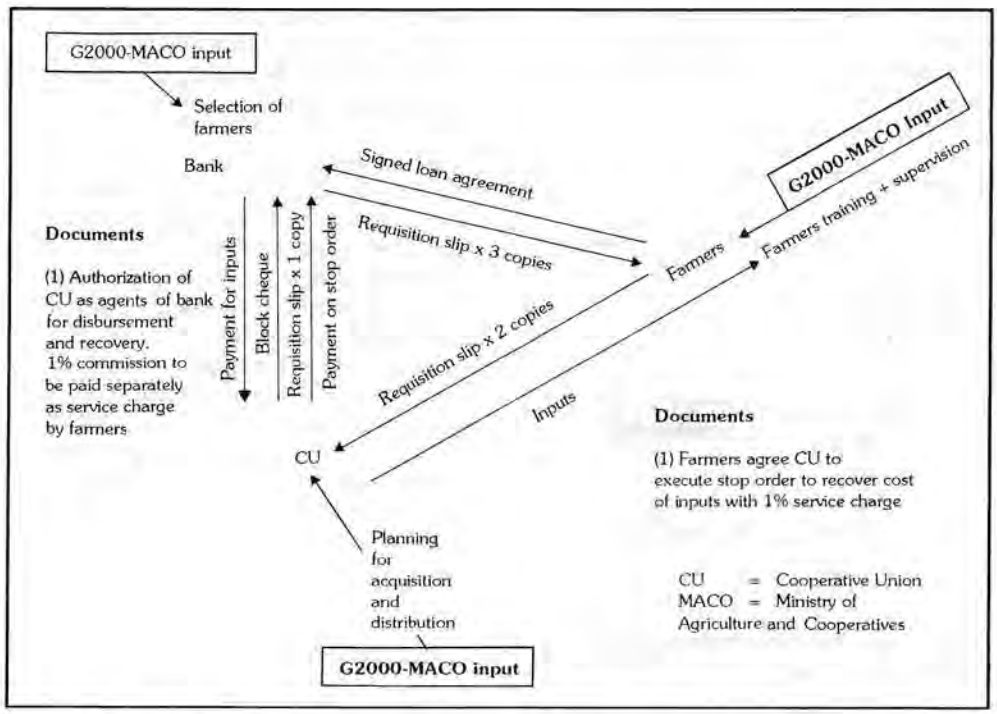


Figure 7. Global 2000-BCCI/MACO - Loan Scheme for Small-Scale Farmers, 1988-89

outstanding model for other countries in which BCCI has operating banks. This will of course depend on the recovery rates. The BCCI loan scheme is illustrated in **Figure 3.**

Training and Linkages--The program is concentrating to increase the efficiency of extension officers. In each operational area 2-4 training courses were organized. This exercise gave the opportunity to about 300 extension staff to participate in the training program, meet the research scientists and to share ideas. Additionally, field survey visits were arranged for the extension staff to learn about the progress in other operational zones.

Training and frequent farm visits are very important for the successful implementation of the program and strengthens linkages between extension staff, researchers and farmers. Extension officers serve as a bridge between the research and farmers for two way flow of information (**Figure 4**).

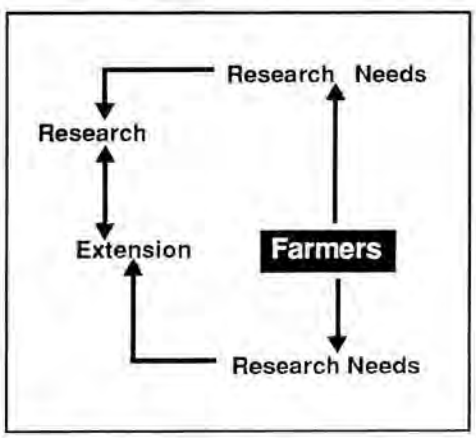


Figure 4. Flow of technology transfer from research stations to farmers

A total of 387 field days were organized, involving approximately 22,000 farmers who attended to learn about the new methods of maize and sorghum production (**Table 7**).

Future Projections

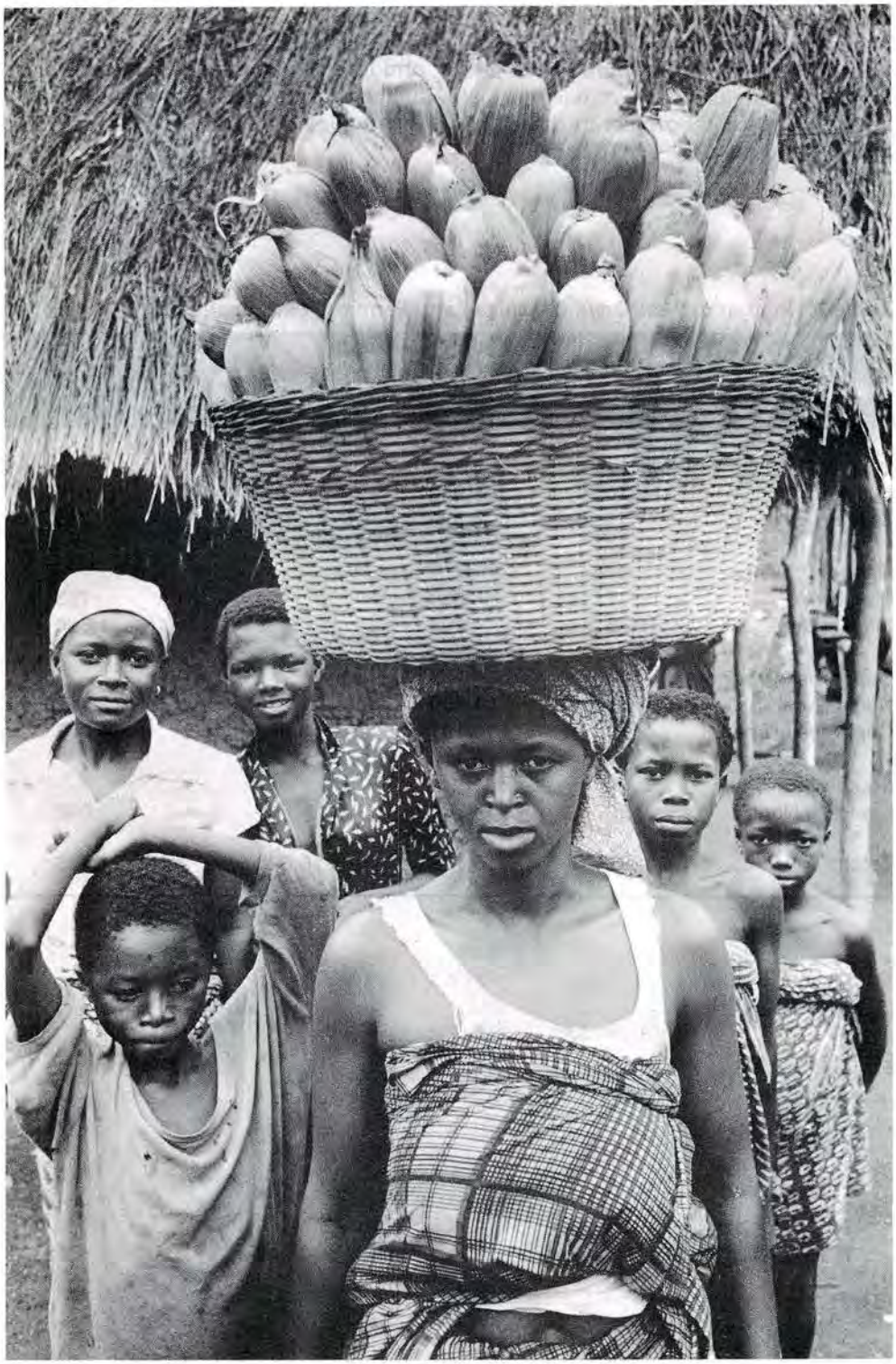
Presently the program is concentrating on hand hoe farmers in four of the nine provinces of Zambia. There is need to expand the program to other provinces. Plans are underway to extend the project activities to Eastern Province from next cropping season. Eastern Province has a maximum concentration of small-scale farmers in the country and grain yield per unit area is considerably low. Emphasis will also be placed on the use of oxen by farm families. This will permit the farmers to cultivate more area. Field operations like land preparation and planting require more labor and hand hoe farmers find it difficult to manage large area under better management.

To enhance the adoption rate of improved technology, the bank has been requested to consider giving short term commodity loan for 30,000 production units in project area in the 1989-90 cropping season. Each unit will be of two Limas (0.5 ha) and farmers can apply for loan to grow up to 6 units depending on the farmers' own resources to cultivate the area. In future, a loan scheme for the purchase of oxen is planned to alleviate labor bottlenecks during land preparation.

By the end of the first phase, the program will be operating in almost half of the country. It should then be possible to measure the impact of the Global 2000-BCCI project in the operational area by 1991. The demand for seed, fertilizer and credit facilities is showing an upward trend and likely to increase on a faster rate as more and more farmers use the technology.

Table 7. Number of Field Days Organized and Farmers' Participation in 1988-89

District	Field days	Attendance		
		Male	Female	Total
		No.		
Lusaka Province				
Lusaka	40	1,010	609	1,619
Kafue	11	322	393	715
Central Province				
Mumbwa	7	660	135	795
Mkushi/Serenje	75	995	505	1,500
Copperbelt Province				
Ndola Rural	41	1,569	533	2,102
Copperbelt Urban	176	10,191	3,882	14,073
Southern Province				
Gwembe North	37	361	571	932
Total	387	15,108	6,628	21,736



The Development Strategy in Agriculture for Ghana

Commodore S.G. Obimpeh (Rtd.)
PNDC Secretary for Agriculture

Mr. Chairman, former U.S. President Mr. Jimmy Carter, Mr. Ryoichi Sasakawa, Chairman, Japan Shipbuilding Industry Foundation, colleague Secretaries of State, your excellencies, distinguished Scientists, Ladies and Gentlemen.

It is indeed a great pleasure for me personally to have the singular honor of discussing Ghana's development strategy in agriculture before such an august body.

Before going into our future strategies, however, Mr. Chairman may I crave your indulgence to briefly narrate to the distinguished participants the history of Ghana's agricultural development over the past 30 years; that is, since our independence in 1957. I believe this approach will enable participants to better appreaciate the rational behind our policy reforms under the Economic Reform Program, and hence our new agricultural strategies and tactics.

At the onset of independence Ghana had one of the highest incomes in Africa which would have placed it among the middle-income countries by today's standards. Ghana's per capita income of $354 in 1950 was highest among West Africa states and in 1950 was more than double the average for Africa. Even at the time of inauguration of ECOWAS (Economic Community of West African States) in 1975, Ghana's per capita income of $427 was second only to Cote D'Ivoire's $460, but five years later, in 1980, her per capita income ranked fifth after the Cote D'Ivoire ($1,150); Nigeria ($1,010); Liberia ($530) and Senegal ($450). This situation arose because over the period 1950-80, per capita income grew at only 0.5 percent per year. The slight positive growth was the result of rapid growth between 1950 and the early sixties. Thus, the per capita growth rate declined from 2.1 percent between 1950 and 1960 to 0.5 percent from 1960 to 1970 and to 1.2 percent between 1970 and 1980.

A continuous decline in per capita income after the early 1960s increased the incidence of absolute poverty, worsened income distribution, and reduced efforts at poverty alleviation. The existing economic situation prior to the launching of Ghana's Economic Recovery Program in 1983 was the cumulative effect of a downward economic spiral which had its major roots in reduction in the output of the key productive sector of agriculture. This reduction in

agricultural output, in turn, was the result of policy choices which were made from misdiagnosis of alledged market imperfections in both factor and product markets, which resulted in policy-induced domestic distortions inimical to growth, equity and poverty alleviation.

On the macroeconomic level, an overvalued exchange rate kept the Cedi cost of imported goods low and penalized the export of Ghanaian products. The unwillingness to devalue led to complex systems of import licensing necessary to ration scarce foreign exchange resources. The result was extreme isolation of the official Ghanaian economy from the international market, as scarcity and risk premia raised effective market prices for basic commodities to levels far in excess of their international equivalents.

Under public sector management, input distribution grew increasingly inefficient. In addition, agricultural producers had to contend as well with deteriorating economic incentive structure as agriculture (especially the industrial crop sector) became heavily taxed. For example, cocoa farmers in 1983 received 21% percent in real terms of the producer price they received in 1970, cotton farmers in 1982 received 9 percent of 1970 prices, while tobacco farmers in 1984 received 38 percent of 1970 producer prices (**Table 1**). Producers responded either by reducing acreages (in 1983 cotton production

Table 1. Official Producer Prices (Cedis/ton) Deflated Using Rural CPI

Year	Cocoa Beans	Seed Cotton	Tobacco	Maize[a]	Cocoa Beans	Seed Cotton	Tobacco	Maize[a]
	(Current Cedis)				(Constant Cedis) Index			
					(70=100)	(70=100)	(70=100)	(77=100)
1970	299	180	810		120	100	100	
1971	293	180	960		90	92	109	
1972	293	180	1,110		82	84	115	
1973	366	180	1,180		88	71	104	
1974	439	220	1,190		90	75	90	
1975	561	220	1,770		90	58	105	
1976	602	770	1,860		61	129	69	
1977	788	770	2,100	240	35	59	36	100
1978	1,333	1,320	3,560	800	35	58	35	191
1979	2,743	1,320	5,850	1,000	46	37	36	150
1980	4,000	1,320	10,730	1,650	41	23	41	153
1981	4,000	1,320	25,000	3,000	20	11	46	133
1982	12,000	1,320	25,000	5,000	49	9	37	181
1983	12,000	10,710	80,000	18,000	21	31	52	284
1984	20,234	14,000	80,000	18,000	26	30	38	205
1985	56,600	25,000	125,000	20,000	66	49	54	210
1986	85,000	28,000	142,000	26,000	81	45	N/A	225
1987	140,100	32,000	N/A	42,000	98	47	N/A	265
1988	165,000	40,000	N/A	48,000	115	N/A	N/A	302

Source: Ministry of Agriculture
[a]GFDC recommended purchase price.

was 25 percent of its average in 1975-77, while tobacco production was 20 percent of its average level in 1974-76) or by smuggling output (cocoa) into neighboring countries for sale.

The net result of post-independence economic strategies is that most growth oriented economic activities were squeezed out of the official onto the parallel market and agriculture was forced to operate well below its production possibility frontier.

The Goverment of the PNDC having recognized that past economic strategies had squeezed most economic activities out of the official onto the parallel market, embarked on a comprehensive Economic Recovery Program (ERP) in 1983, with financial support from the World Bank and the IMF.

The PNDC's Economic Recovery Program launched in 1983 constituted the first serious attempt in two decades at addressing issues relating to the proper management of macro-economic and structural adjustment policies in the Ghanaian economy.

For the agricultural sector, the period 1983-1985 was devoted to initiating a number of ad hoc programs designed to overcome the prevailing hunger caused among other things, by the 1983 drought and its attendant bushfires as well as the return of over 1 million Ghanaians from Nigeria. The main objectives were (1) to mobilize all available human (Returnees) and other resources to increase the production of the major staples (maize, cassava, plantain, cocoyam, rice), (2) to reclaim abandoned cocoa and oil palm plantations, and (3) to replant cocoa farms devastated by the 1983 bushfires. Indeed, it became necessary to close down the Ministries before 5 p.m. to enable as many people as possible attend to their farms.

These ad hoc programs had the good fortune of good rainfall and the country became almost self-sufficient in maize and oil palm production in 1984. By 1985, however, the absence of a National Agricultural Policy designed to increase agricultural productivity on a sustained basis was felt. The good harvest of 1984 led to sharp decline in output prices in the absence of a well designed storage programe to handle the surpluses. Farmers reacted to the low output prices by reducing their production in 1985. For example, maize production which fell to all time low of 141,000 metric tons in 1983 increased to 574,000 in 1984 but fell to 411,000 metric tons in 1985 due mainly to the adverse effect of the 1984 low maize prices (prices fell from c$10,000 per 100 kg bag in 1983 to c$600 in 1984).

The ERP helped to reverse the downward decline in the production of agricultural commodities such as cotton, tobacco and foodcrops even though the recovery program placed emphasis on the cocoa, timber and mining sub-sectors.

A review of the ERP's performance in 1985, as well as an assessment of medium-term prospects led to the conclusion among other things, that one of the fundamental aims of the ERP over the 1986 - 88 period ought to involve the shifting of the leading edge of policy reform from macro-

economic to sectoral concerns, and the laying of emphasis on the basis for renewed, vigorous and efficient growth in the key sectors of agriculture, energy, industry, education and health.

The Ministry of Agriculture therefore took the initiative to organize a national debate on agricultural policy direction over the 1986-88 period. The debate resulted in the Publication of Ghana's Agricultural Policy, Action Plans and Strategies, 1986-88, in January 1986.

During the implementation of the first phase of the ERP, it was found that the MOA and other organizations created to support the agricultural sector were weak and ineffective because of the woeful neglect of past governments. This resulted in an agreement on a program to tackle short term adjustment issues which were to be supported by a Structural Adjustment Loan (SAL). As part of this work, the World Bank undertook an Agriculture Sector Review which identified the main elements of a strategy to promote agricultural development. This led to the launching of a $53.5 million Agricultural Services Rehabilitation Project (ASRP) in 1987. The emphasis of this project is on strengthening the capacity of the public sector to support Research, Extension Services, Irrigation and Policy Planning, Monitoring, Evaluation and Coordination, and to make the required investments for expanded agricultural production.

The basic objective of the project is to initiate a self sustaining process of rehabilitation so that MOA can give more effective support to agriculture. Specifically, it has three inter-related objectives:

(a) to strengthen the institutional framework for the formulation and implementation of agricultural policies and programs;
(b) to improve the delivery of public sector services to agriculture;
(c) to improve the procurement and distribution of agricultural inputs.

These objectives are gradually being attained despite initial teething problems encountered notable among which was the unfamiliarity with the IDA procedures by the Project Coordinating Unit (PCU) coupled with under staffing of the Unit. These problems have however been resolved. It is hoped that by the end of the project period in 1992 a self sustaining program to rescue the sector to enable it contribute more effectively to Ghana's economic growth would have been evolved.

Recent Changes in Economic Incentives

Recent figures show that the economy has begun to respond to the initiatives taken in 1983. Real GDP increased by 10.7 percent in 1984, helped by a more normal rainfall after five successive years of decline. A further increase of 6.1 percent in GDP was recorded in 1985 to bring the GDP to 2 percent below the production peak which occurred in 1974.

Agricultural output grew by nearly 14 percent in 1984, accelerated by good rainfall and improved input

supplies, and accounted for about 55 percent of GDP. A further growth in agriculture of 5.3 percent was recorded in 1986 and 6.0 percent in 1988 after a slight decline in 1987 due to drought.

The series of re-alignments in the local currency, the Cedis vis-a-vis other convertible currencies, and the subsequent increases in agricultural output prices, have had an enormously favorable impact on the comparative advantage of Ghanaian agriculture, including export and foodcrops as well as import-substitution crops.

In 1988, for example, 65 different non-traditional agricultural commodities valued at $27,000,000 were exported to destinations all over the world. Non-traditional agricultural commodity exports represented 64 percent of the total non-traditional exports for that year, and the self-sufficiency ratio for maize, rice, sorghum and millet reached an all time high of 77 percent from a low of 35 percent in 1983.

Furthermore, the $27,000,000 earned in 1988 from non-traditional agricultural exports represents a 44 percent increase over the 1987 earnings. Thus for the first time in many years Ghana's dream of diversifing the sources of its agricultural export earnings is being fulfilled due to the positive impact of the Economic Recovery Program of 1983 on the entire agricultural sector. Even more encouraging is the fact that the traditional division between export crops and foodcrops is gradually becoming irrelevant as every agricultural commodity in Ghana today has become a potential export crop.

Medium-Term Agricultural Development Program 1990-1995

In spite of the positive response to the policy reforms initiated in 1983, agriculture still faces a formidable task in maintaining the momentum of the recovery in view of the still relatively poor state of the economic, social and administrative infrastructure and the depleted manpower base.

In order to consolidate the gains so far made in the agricultural sector, My Ministry, in collaboration with the World Bank, has initiated the preparation of a rolling 5-10 years Medium-Term Agricultural Development Program (MTADP) which will define medium-term agricultural development priorities, identify key policy and institutional reforms and prepare a medium-term expenditure program. The MTADP is expected to provide a framework for the efficient allocation of public and private sector resources and a focus for policy and institutional reforms in the agricultural sector in order to fully realize Ghana's agricultural potential. The MTADP will also provide a framework for donor assistance in the agricultural sector and rationalize the rather uncoordinated activities of the several NGOs that are operating in the agricultural sector. The MTADP will thus dovetail into the ASRP.

The major objective of the Government during the Medium Term is to pursue a demand-driven national agricultural strategy whose goals are development-oriented, productivity-enhancing and competitiveness-promoting. This is based on the belief that Ghana's vast

agricultural potential can only be exploited fully in a systematic, cost effective and sustained manner if and only if Ghana's agricultural production is driven by strong domestic and foreign demand.

This domestic and foreign demand driven approach to Ghana's agricultural development is consistent with the observation that at the start of the 1960s, 10 percent of world agricultural production was traded among nations. By 1980, this figure became 17 percent and it is expected to reach 25 percent by 1990. The significant trend worldwide is in the food industry as opposed to the production end of agriculture where only incremental changes are occurring. The food industry has moved from selling the raw commodity, to selling the partially formulated product, to selling the wholly formulated product. As a result of this shift in emphasis, market segmentation is becoming increasingly important. Policy makers must therefore be sensitive to the desires and needs of their domestic and foreign consumers. There are now significant opportunities for the development of national and regional private companies with limited (niche marketing) product lines as improved market information identifies more and more specialized markets.

In particular, the medium-term strategy is expected to:

(a) provide all Ghanaians with food security by way of adequate and nutritionally balanced diets at affordable prices both now and in the future;
(b) promote increased smallholder productivity and ensure that all efficient agricultural producers earn incomes that are comparable to those outside agriculture thus making agriculture an attractive employment alternative to industry, trade and commerce;
(c) ensure that agricultural contributes effectively to the country's balance of payments position through export diversification and import substitution;
(d) establish effective linkages between agriculture and industry; and
(e) result in balanced regional development and growth based on comparative advantage and resource endowment.

The Crop Sub-Sector

The strategy in the crop sector will seek to promote agricultural production through increased smallholder productivity, reduced post harvest loss, marketing and distributional costs, as well as processing of horticultural crops, industrial raw materials, and the non-traditional export crops.

The Livestock Sub-Sector

Ghana's meat demand is expected to reach 300,000 tons by the Year 2000. In order to meet at least 50 percent of this demand from the current 25 percent, our strategy aims at encouraging increased private investments in the production of poultry, pigs and small ruminants. In the medium to long term, we will be encouraging investments in our cattle industry for the production of both dairy and beef. The immediate

priority in the livestock sector is to re-establish an effective national programme of disease control and improved husbandry practices which together will offer substantial increases in production quickly through reduced animal mortality and increased productivity. To this end, a revolving fund for the purchase of feed ingredient, drugs and vaccines has already been established.

The Fisheries Sub-Sector

The strategy in the fisheries sub-sector is designed to encourage sustainable exploitation of Ghana's vast marine and fresh water potential through attractive investment opportunities in the exploitation, processing and marketing of tuna as well as the development of acquaculture for fresh water fish, prawns and shrimps etc.

There is a special incentive scheme that allows up to 90 percent of the tuna caught to be exported to enable investors quickly recover their investments. There are additional attractive avenues for the use of fish waste and anchovy for the preparation of fish meal to support the poultry and pig industries.

In specific terms, Ghana's major agricultural objective over the period 1990-1995 will be to achieve an overall annual growth rate of 6 percent while moving from the unbalanced agricultural base as recorded in 1988 to a more balanced base by the year 1995 in **Table 2**.

Table 2. Ghana's Agricultural Base: 1988 and 1995

Commodity Group	1988 Contribution to Agric. GDP by Value (%)		1995 Contribution to Ag. GDP by Value (%)	
Roots/Tubers	55	(6.2)	40	(2.5)***
Cereals	7	(0.1)	10	(1.0)
Industrial Crops*	1	(0)	3	(0.5)
Vegetables	2	(0)	3	(0.2)
Cocoa	14	(-.1)	15	(0.5)
Fish	5	(-.01)	8	(0.5)
Livestock	4	(0)	7	(1.0)
Forestry and Non-trad.	12	(n/a)	15	(n/a)
Export Crops**				
Total		100%		100%
Overall Growth Rate				6%

* Industrial crops include palm oil, cotton, tobacco and groundnuts.
** Non-traditional export crops include pineapples, copra and rubber.
*** Figures in Brachets indicate respective contribution of growth rates in 1988 and those expected by 1995.

Food Security

The magnitude of food insecurity has not yet been fully quantified. However, the calorie supply in relation to total requirements and a reliance on the market for basic food supply in the face of declining real incomes, point to insecurity of food supplies. MTADP will concentrate on options for increasing both cereal and tubers/root crop production, as well as animal protein, and on mechanisms for improving marketing efficiency. The detailed treatment of demand will await the results of the Food Security Study being initiated by MOA, which begins in August 1989 and is expected to be completed by December 1990. The study, among other things, is supposed to deal with the important issues of access to food.

Creating Rural Employment Opportunities

Agriculture provides emplyment directly for at least two thirds of the working population. Data on the sectoral distribution of employment shows that agriculture, including forestry and fishing, employed about 57 percent of the labor force in 1970, 61 percent in 1984 and 66 percent in 1987. The share of the agricultural sector in total employment continues to rise. The Ghana Living Standard Survey (GLSS) data indicates that open unemployment may not be severe in rural areas. Given that productivity has been stagnant, disguised unemployment must have risen while incomes declined. The main objective is therefore to reduce under-employment by raising labor productivity in production, marketing and value added activities.

Improvements in the Balance of Payments

Agriculture contributes about 75 percent of the total foreign exchange earnings, derived mainly from cocoa and timber. The Government intends to achieve its objective of increasing foreign exchange earnings by increasing the production of traditional agricultural exports (cocoa and timber), and diversifying into other non-traditional exports (horticulture, rubber, coffee, tobacco) as well as increasing the production of import substitutes. The objective of increasing net export earnings is therefore closely tied to the issues of export promotion, import substitution (rice, palm oil, cotton), and agricultural export diversification. The pressure to "do something" about the level of export earnings has been heightened recently by the gloomy forecast of international cocoa price trends and the consequent strain it is likely to put on the balance of payments.

It has been advocated that industrial production should be domestic-resource based. Thus an effective linkage between agriculture and industry would ensure that agriculture provides raw materials for industry while industry provides inputs to agriculture. A diversified agriculture, therefore, may lead to varied industrial products. The growth of agriculture will also create demand for industrial goods as the income of the farmer improves from increased on-farm productivity, reduced marketing, processing and distributional costs.

Balanced Regional Development

The Government intends to pursue a policy of balanced regional development through the promotion of regional agricultural growth based on comparative advantage and resource endowment.

The Ministry of Agriculture is convinced that the long-term viability of Ghana's agriculture depends on being competitive in the world market. To this end the Ministry intends to pursue policies that will drastically bring down domestic prices as a result of substantial increases in yields through the effective adoption of high yielding improved varieties and proven and locally available technological packages to increase the efficiency of farmers, herdsmen, fishermen, processors and distributors.

In particular, one of the specific objectives of the Ministry under the Medium-term Plan is to raise the current national average yields, increase the level of food security and expand agriculture's contribution to Ghana's balance of payments. **(Table 3.)**

Summary

In summary, Mr. Chairman, the major objective of the Ministry of Agriculture under the Economic Recovery Program of 1983 has been to motivate the Ghanaian Farmers especially the small-scale farmers, fishermen and herdsmen to increase agricultural productivity. This objective is based on the belief that Ghana's vast agricultural resources can only be exploited to their full potential if and only if the Ghanaian farmer is motivated to increase productivity. The benefits of such increased productivity include: adequate returns to farming, availability of adequate and nutritionally balanced diets to Ghanaian consumers at affordable prices, effective contribution to Ghana's balance of payment position, and the provision of cheap agricultural raw materials for Ghanaian industries.

One instrument the Ministry has been using to encourage increased productivity in smallholder agriculture is the annual review and announcement of minimum guaranteed prices for a number of export, industrial and food crops. These prices are designed to ensure that if farmers are unable to get higher prices for their crops, they can sell their commodities to institutions such as the Ghana Food Distribution Corporation (GFDC) at the minimum guaranteed prices and obtain at least 25 percent profit on their investments provided they achieve a certain minimum level of agricultural productivity.

Special attention has been given to the retraining and motivating extension workers to enable them effectively extend the good work initiated under the Sasakawa-Global 2000 program.

Ghanaian farmers have responded positively to the PNDC's policy initiatives and the timely provision of adequate supplies of inputs such as fertilizers and agro-chemicals.

For example, maize, rice, sorghum and millet production reached an all time high self-sufficiency ratio of 77 percent in 1988 from a low rate of 35 percent in 1983 and a high of 73 percent in 1976. In addition, a total of 65 non-traditional agricultural

Table 3. Expected Achievements by 1996

Item Commodity	Current national average yield tons/ha	Expected national average yield tons/ha	% Increases in distribution, marketing and processing (value-added)
Root/Tubers			
Cassava	5.0 - 6.0	10.0	30
Yam	4.5 - 5.0	7.0	25
Plantain	5.0 - 6.0	8.0	10
Cocoyam	5.0 - 6.0	7.0	-
Cereals			
Maize	1.0 - 1.2	2.5	50
Rice	0.8 - 1.2	2.0	-
Sorghum	0.8 - 1.0	2.0	25
Millet	0.6 - 0.8	1.5	25
Industrial Crops			
Oil Palm	5.5 - 6.0	7.0	50
Cotton	0.4 - 0.6	1.0	30
Tobacco	0.8 - 1.0	1.5	10
Non-Traditional **Export Crops**			
Pineapple	2.9 - 3.2	4.0	50
Coconut	6.0 - 7.0	9.0	50
Rubber	0.8 - 0.9	1.5	50
Post Harvest Loss			
All Crops	20 - 30%	10-15%	
Meat Requirement	25% of National Requirement	50% of National Requirement	
Fish	60% of National Requirement	80% of National Requirement	25% (Tuna)
Agricultural **Non-Traditional** Export Earnings	$27 million	$100 million	
Employment	1.4 million Farm House-holds	200,000 additional Employment opportunities in marketing processing, and distribution	
Access to Food	Currently over 80% of average incomes on food	Not more than 50% of average incomes on food	
Agro-Industry Linkage	Agric. provides less than 20% of most agro -industrial raw materials	Agric. to provide 50% of agro -industrial raw materials	50%

products were exported by 700 exporters earning over $27 million in 1988, and increase of 44 percent over export earnings in 1987.

Preliminary yield estimates indicate that agricultural growth in 1989 will be similar to the 6 percent achieved in 1988. However, as agriculture continues to make significant progress under the ERP, the problems of farmers' limited access to credit: high cost of farm labor, the poor state of most feeder roads, resulting in high marketing costs and therefore low returns to farmers as well as the limited demand avenues for Ghana's agricultural products in both the domestic and foreign markets are fast becoming major constraints to agriculture's further growth and development.

The Ministry of Agriculture believes that the long-term survival of Ghana's agriculture depends on increasing the demand for Ghanaian agricultural products in both the domestic and foreign markets as well as increasing farmers access to credit to enable them pay for productivity increasing technological packages currently available.

Another way of encouraging rapid agricultural growth and development is for industry to step in to expand the domestic and foreign demand base through the use of agricultural surpluses as industrial raw materials.

The Ministry strongly believes that Ghana's Agriculture is ready to takeoff into self-sustained growth to the benefit of all Ghanaians be they producers, consumers or distributors if the problems of access to credit, industrial use of agricultural surpluses and high cost of transportation are addressed once and for all.

In conclusion, Mr. Chairman, ladies and gentlemen let me take this opportunity to express the appreciation of the Government and the people of Ghana for the positive achievements of the Sasakawa-Global 2000 program in Ghana.

This is an achievement that the originators of the programme as well as the people of Ghana can justifiably be proud of since whatever has been accomplished has been done through very close cooperation between the Global 2000 team, the participating farmers and the entire Ghanaian leadership.

As we move towards the implementation of the Medium Term Agricultural Development Plan, the Ministry would appreciate the cooperation and understanding of donors and other agencies such as the Sasakawa-Global 2000 to make the program a success worthy of emulation.

The Role of Economic Policy in Transforming Agriculture in Food-Deficit Third World Countries

G. Edward Schuh *

It is a pleasure to be part of this important workshop which focuses on ways to improve agricultural technology generation and delivery systems in basic food crops in Ghana and other sub-Saharan countries. It is a double pleasure to be able to discuss one of my favorite topics, the role of economic policy in transforming agriculture in food deficit developing countries.

My paper is divided into three parts. First, I will present a policy perspective on food- deficit developing countries. In developing this perspective I will discuss how economic policy often contributes to making developing countries be food deficit, and then explain why a broad perspective to policy is needed if agriculture in such countries is truly to be transformed. Second, I will discuss the role of new production technology in transforming traditional agriculture and why it is so important. Third, I will discuss the policy imperatives required to bring about the needed transformation of agriculture. Finally, I will have some concluding comments.

A Policy Perspective on Developing Countries

The first question we need to ask is why developing countries are so often food deficit, especially when so many of them are well endowed with natural resources, with a major portion of their population employed in agriculture. The explanation lies in two important characteristics of such countries. First, they significantly under-invest in the human capital needed to modernize their agriculture. Second, their economic policy discriminates severely against their agricultural sector, which is to say that policy makers do not provide adequate economic incentives for their agricultural producers. Let's consider each of these in more detail.

First, consider the issue of under-investing in human capital. The first and perhaps most important issue is the under-investment in agricultural research and in the extension system needed to take the results of that research to the producer. If there is anything we know about agricultural development it is that the rate of return to society from investing in agricultural research is quite high. A large number of studies have made which estimate these rates of return. (See Ruttan for a survey of the results.) These studies almost uniformly show that the rates of return are quite high - ranging as high as 40 to 60 to 80 to over 100 percent in perpetuity.

These are extraordinarily high rates of return, and much higher than the rates of return on commercial ventures in those countries or on

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other public investments governments make. What these high rates of return mean is that investing in agricultural research is a cheap source of economic growth. The marvel is that governments continue to under-invest in such cheap sources of growth, especially when they can borrow money from the World Bank and other development banks to make such investments at interest costs on the order of 7 to 8 percent per year.

Right behind the failure to invest in agricultural research is the failure to invest in the training and education of their agricultural labor force. There are two dimensions to this under-investment. The first is the failure to develop the higher-level educational institutions to train the cadres for a modern agriculture. This includes the staffs for modern research and extension systems. It also includes the staffs for modern credit systems and other parts of the social infrastructure.

The second dimension to the problem is the failure to provide elementary and secondary schooling for the agricultural population at levels comparable to those for the urban population, training which can provide the vocational skills needed for a modern agriculture. Schooling and training are needed not only to modernize agriculture, but also to help labor transfer to non-farmer employment as agricultural modernization proceeds. This adjustment of labor is needed if per capita incomes in agriculture are not to lag behind those in the non-farm sector. (See Schuh and Schuh.)

Developing countries also under-invest in the provision of health care services for their rural population compared to that for their urban populations. This leaves their agricultural population weakened and less productive as workers. It also makes young people less able to absorb the cognitive skills provided by what limited educational systems they have.

Finally, rural populations tend to be undernourished. This has little to do with issues of self-sufficiency, as commonly believed. It has almost everything to do with the pervasiveness of poverty among rural populations, and the lack of targeted feeding programs for those disadvantaged.

The second set of factors which explains why developing countries tend to be deficit in the production of food is that governments discriminate severely against their agricultural sectors with their economic policies. Unfortunately, policy makers in these countries spend far too much time railing against supposed declines in their external terms of trade. They spend far too little time understanding what their own economic policies do to their internal or domestic terms of trade - something over which they have some control.

The truth of the matter is that policy makers in developing countries implement a panoply of polici s which discriminate against their agriculture by shifting their domestic terms of trade against agriculture. These include grossly overvalued currencies, large explicit export taxes, barriers against exports of agricultural exports, protection of manufacturing sectors which make the costs of inputs and other items purchased from the non-farm sector higher than they would otherwise be, and marketing boards and other parastatals which buy

cheap from producers and sell dear abroad, or which tax farmers in other implicit ways. It is little wonder that levels of private investment in agriculture are so low, or that farmers have so little incentive to work and develop their resources.

This configuration of economic policies explains directly why so many developing countries are net importers of food. After all, an overvalued currency is equivalent to an export tax and to a subsidy on imports. It is little wonder that export performance is weak and imports eventually burgeon out of control. In effect governments are willing to pay more to producers in other countries--typically the producers in the well-to-do developed countries--than they are to their own producers. It would be difficult to devise a more short-sighted set of policies. The other policies identified above only further exacerbate these problems.

Two related issues are important about these policies. The first is the high degree of complementarity between science and technology policy, on the one hand, and economic policy, on the other. New production technology will be adopted more rapidly if farmers have the proper incentives. By the same token, it doesn't matter if a research system is available to produce the technology for a modern agriculture if farmers do not have the incentives to invest in their productive activities and to adopt that new technology.

The second thing that is important about these policies is that a broad perspective is needed on economic policy. Policy has to consider more than the usual commodity policy and credit policy which policy makers (and often agricultural economists) conventionally emphasize. Instead, a general equilibrium perspective is needed so that all the policies which affect the domestic terms of trade are considered. These include trade policies which affect both the farm and non-farm sectors, monetary and fiscal policies, exchange rate policies, general credit policies, and labor market policies. This is a tall order, but nothing less than such a broad perspective will address the key issues.

The Role of New Production Technology in Transforming Traditional Agriculture

In a sense, this topic goes beyond my original assignment. But it is very important to understanding why proper investment and price policies are so critical to agricultural modernization.

This issue is important because of the general failure to understand how new production technology--the output of agricultural research--contributes to economic growth, and why it does so in such a powerful way. The general tendency is to believe that the benefits of agricultural research ultimately go to producers, and that it is for their benefit that agricultural research should be undertaken. This perspective misses a great deal of what is important.

Let's consider for a moment how new production technology affects the economy. If the agricultural research effort has been a successful venture, the result will be, for example, an improved variety that results in significantly higher yields. Such an improved variety will raise the

productivity of all the resources used in the production process--labor, land, and the other capital tools and instruments used in the production process. So long as the price of the output does not change, this increase in productivity will raise the income of farmers. It is for this reason that it is easy to believe that the farmers are the beneficiaries of the new technology.

However, think for a minute about the consequences of the increase in output that results from this productivity-enhancing new technology. This increase in supply relative to demand will result in a decline in the price of the commodity. The gains of the producers will be eroded. But consumers will benefit. In fact, a decline in the price of a staple commodity is equivalent to an increase in the real incomes of consumers. The more important the commodity is in the consumer food basket, the larger this increase in income will be. Moreover, if the commodity should be a necessity, its demand will tend to be inelastic to the change in price and the decline in price will be greater the more essential the commodity.

What we see is that the effects of adopting the new production technology is pervasive in the economy. If we think about this process applying to the entire food and agricultural sector, we see that all consumers benefit from the introduction of new technology. That explains why the rate of return to such investments is so high. But there is another dimension to this process that is equally, if not more, important. That is that low income people in society spend a larger share of their budget on food. As a consequence, low income consumers tend to benefit more in a relative sense from the availability of new technology for the food sector. Thus the introduction of new technology in staple crops tends to have progressive income distribution consequences.

Unfortunately, those who have studied the income distribution effects of introducing new production technology into agriculture tend to focus only on the effects on the distribution of income on the producer side. Given that it is the large and more progressive producers who tend to adopt the technology first, the appearance is that the introduction of new production technology results in a worsening in the distribution of income. That conclusion is reached, however, only by ignoring the very real positive effects on the distribution of income when the effects on the consumer side are taken into effect.

There is still another important issue which needs to be considered. If the commodity for which new production technology becomes available is an export crop, or a commodity which is being imported, the longer term effect on the price of the commodity will be nil or very modest so long as the country is unimportant in international trade. In this case there will be no direct benefits to the consumer. However, there is another effect which can have a powerful effect on economic growth. In this case there will be an increase in foreign exchange earnings as a consequence of the increase in output. These foreign exchange earnings can be used to finance a higher rate of economic growth, and

the population will benefit as workers or laborers, and potentially as consumers. The distribution of benefits may not be so pervasive as in the case of new technology for a staple. But the benefits can be substantial.

The production and distribution of new technology for food crops can also have a pervasive effect in making a country more competitive in international trade. This potential derives from the fact that food is a wage good. Workers tend to spend a major share of their budget on such commodities. Hence, decline in their prices makes it possible for real wages to increase even though nominal wages do not change. Thus nominal wages may be lower than they otherwise would be and the manufacturing sector will be able to compete more effectively in international markets, earning more foreign exchange and thus financing a higher rate of economic growth.

We should also note, in concluding this section, that new production technology does make it possible for those producers who remain in agriculture after the technological transformation to earn incomes comparable to those in the non-farm sector. That increase in income comes as labor migrates out of agriculture and farms become larger. It is part of a complicated adjustment process, and is an important equity problem in its own right. A discussion of that problem goes beyond our present interests.

The Policy Imperatives

There are some six imperatives of policy if economic policy is to play a positive role in the transformation of agriculture in developing countries. It is these six policy imperatives that I want to discuss in this section.

The first is the need to fix absolute and relative prices in the economy so as to realize the comparative advantage the country has as a result of its resource endowment. In practice, that means that prices of tradeable commodities (exports and those which compete with imports) should be set at their border price equivalents. In effect that means that there should be no discrimination against agriculture, and compared to the present situation in most developing countries, prices of tradeable agricultural commodities should be raised to levels consistent with those in international markets. It also means that there should be no protection of the manufacturing sector other than that consistent with infant industry arguments. In most developing countries that means that domestic prices for many manufacturing products will be lowered to their border price equivalents.

Many people in developing countries question whether they should be concerned about comparative advantage at all, and argue that such a posture is far too passive if they are to promote rapid rates of economic growth. The issue is whether there is any other criteria to use as a guide other than sheer and hoccery. The point of using

international border prices as a guide for domestic prices is that they are efficiency prices. They indicate the trading opportunities the nation faces.

What often fails to be appreciated by policy makers in the developing countries is that the failure to use efficiency prices is to sacrifice output and income. If policy makers would only ask themselves when they intervene to distort prices away from their border price equivalents, "do I really want to sacrifice national output and income for this alternative goal?", they might well be less inclined to intervene.

There is also nothing in the perspective I sketched out above to suggest a passive posture to international price relationships, or a failure to actively promote economic development. It is perfectly reasonable to try to change a country's comparative advantage. The issue is how to do it. The effective way to do it is to invest in R & D and in the other forms of human capital that will change comparative advantage over time. That is a very different thing than providing protection to favored sectors, or than shifting the domestic terms of trade against particular sectors--infant industry arguments aside.

The corollary to realizing comparative advantage is to make agriculture profitable. This is not to argue for an agriculture-first posture in policy, or to argue for food self-sufficiency, or for an imperative to be a net exporter. Instead, it is to argue that in most developing countries some part of agriculture will have a comparative advantage in international markets, and that those sectors have to be profitable if private decision-makers are to adopt new technology made available to them and invest at rational levels in the sector. Shifting the domestic terms of trade back to levels consistent with international border price equivalents will restore this profitability for those sectors.

The third policy imperative is to raise investment in the sector to socially optimal levels. The previous paragraphs have addressed the issue of private investment. The issue in the present context is the level of public investment, for this is every bit as important as the level of private investment.

D. Gale Johnson often refers to three classical under-investments in agriculture-- under-investments that are universal in both developed and developing countries. His point is that all countries tend to under-invest in agricultural research (as indicated by the very high social rates of return to such investments), they tend to under-invest in the education of their rural population, and they tend to under-invest in the physical infrastructure for the rural sector. All three of these are important in the case of sub-Saharan agriculture.

Raising the level of public investment in each of these components of social capital is critical to promoting economic development, and the effects go far beyond the food and agriculture sectors. Moreover, it is not sufficient to argue that a country cannot afford such investments. These are not consumption goods for which such a comment is pertinent. They are investment activities which promote economic growth and thus generate

the income needed to service any borrowing undertaken to promote them. Moreover, government expenditures are often directed to activities with a far lower payoff.

The fourth policy imperative is to improve the performance of domestic credit and capital markets. Unfortunately, there is not sufficient recognition of the importance of properly performing capital markets. A common failing is to put all the emphasis on infusing more funds into the system, with much less attention given to the problem of mobilizing savings and channeling them to the high payoff investments.

Efficient capital markets require true financial intermediaries which mobilize savings from the multitude of private individuals, change their time dimensions, and channel them to high payoff investments. There are few such financial intermediaries in developing countries, in part because of the tendency of policy makers to intervene with usury laws and mechanisms designed to force available deposits towards particular sectors of the economy. This is an important institutional development challenge. The value of efficient credit and capital markets comes to the fore when new production technology which has a high social payoff becomes available.

The fifth policy imperative is sound monetary policy. This is a large topic in its own right and deserves more time and space than we can give it here. There are a number of things worth emphasizing, however. First, the emergence of a well integrated international capital market and the shift to a block-flexible exchange rate system on the international scene puts a much higher premium on sound monetary and fiscal policies. In the present configuration of the international economic system, changes in monetary and fiscal policies affect the economy by inducing changes in the value of a nation's currency, which in turn induces changes in the traded sectors. In most countries agriculture is either an importing or an exporting sector. In many, it is both. The consequence is that agriculture has become more vulnerable to changes in monetary and fiscal policies.

Second, in many respects the present system of bloc-floating exchange rates is the worst of all possible worlds. Individual countries are affected by "third country" effects of policies in other countries which cause implicit realignments in their exchange rates. In addition, the lack of general flexibility in the system means that shocks to the system are channeled to that part of the system that has flexible exchange rates, and in an exaggerated fashion. Countries that have the value of their currency tied to one of these flexible currencies thus suffer the consequences.

Sound monetary and fiscal policies are those which are neutral in their effect on the economy. That means monetary policies which bring about a stable price level, and fiscal policies which balance the national budget on an annual or three-year moving average basis. The real challenge of parastatals, and the basis of pressures for privatization by the donor community, is the need to balance budgets. Until this is done, agriculture will be subject to a great deal of instability so long as the international economy retains its present configuration.

The final policy imperative is the need for sound positive adjustment policies. Agriculture is subject to the need for a number of adjustments as economic development proceeds. The first, and perhaps most important, is the need for a long-term adjustment of resources, especially labor, out of the sector. This secular adjustment problem typically involves the geographic mobility of labor. Second, sectors of the economy that are tradeable are subject to trade adjustments as comparative advantage shifts and as real exchange rates change. Finally, there is the new situation in which agriculture, as a traded sector, has to bear the burden of adjustment to changes in monetary and fiscal policy.

Positive policies to facilitate these adjustments include more generalized schooling among the rural population, expanded training programs that provide vocational skills for the potential migrant, financial support for relocation, and other mechanisms to facilitate resource mobility. The potential gains in resource efficiency and improvements in the distribution of income are substantial from such policies. Seldom do developing countries have them, however.

Concluding Comments

I would like to conclude by emphasizing two important points. First, sound economic policy in today's world requires an international perspective, and sensitivity to the need to take advantage of the international economy for the opportunities it offers. Most developing countries have come through the post-World War II period with our inward-looking perspective. Changing the configuration of policy towards a greater sensitivity to the international economy is not easy, but it must be done.

Second, the configuration of the international economy has changed dramatically over the last 25 years. These changes give a much greater significance to monetary and fiscal policies and their impacts on agricutlure, and unless domestic policy is sound, create the potential for a great deal more instability in agriculture. Challenging as these new conditions are, there is little to be gained either from wishing they had not taken place, or from hoping that we will go back to an earlier day. We have to deal with the realities of the international economy as they are, while working over the longer term for much needed reform of that system.

References

Ruttan, Vernon W., *Agricultural Research Policy*, Minneapolis, University of Minnesota Press, 1982.

Schuh, G. Edward, and Maria Ignez Angeli-Schuh, "Human Capital for Agricultural Development in Latin America," prepared for IICA, San Jose, Costa Rica.

Taking a Fresh Look at Informal Finance[1]

*Dale W. Adams**

During the past several years I have often been asked to name sustainable agricultural credit programs in low-income countries (LICs). Answering these requests causes me embarrassment, disappointment, surprise, amazement, and puzzlement. My embarrassment comes from being able to name so few sustainable programs, despite the tens of billions of dollars committed to hundreds of these efforts. At the same time, I painfully remember large numbers of transitory credit activities that have been plagued by loan recovery problems, chronic dependency on outside funds, and excessive transaction costs. My disappointment stems from seeing little improvement in the performance of these efforts since the mid-1960s when Ohio State University began working on problems of rural financial markets (RFMs).[2] While our understanding of how RFMs function and what causes them to misfire has expanded substantially in the past two decades, only in a handful of cases has this new knowledge been used to treat RFM ills.[3] I have grudgingly concluded that creating sustainable rural credit programs is far more difficult to do than most of us had heretofore thought.

My embarrassment and disappointment are tempered by surprise. In recent research in Bolivia and the Philippines--two countries suffering substantial economic stress--I encountered informal finance thriving amidst the rubble of formal financial markets.[4] It surprised me to see informal lenders recovering most of their

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[1] Many of the ideas in this paper have been gleaned from others who have burrowed more deeply into informal finance than have I. Frits Bouman and Clifton Barton gave me lectures years ago about the importance of informal finance that I am only now beginning to appreciate fully. J.D. Von Pischke, Robert Vogel, and colleagues at Ohio State University have done much of the research and original thinking on which I base my paper. Two anthropologists, Marie Canavesi and Virginia Sandoval, also exposed me to informal finance in Bolivia and the Philippines. I also learned a great deal about informal finance while attending an excellent seminar in the Philippines in early 1989 sponsored by the Asian Development Bank and organized by P.B. Ghate. The references at the end of the paper identify other individuals who have unwittingly influenced my thinking on this topic.

[2] This work was funded by the Agency for International Development (AID) and has involved research in more than three dozen low-income countries. The steady support of our work by numerous AID employees over the years is a proxy for the frustration many of them harbor about rural credit projects.

[3] Readers interested in further details on the problems in rural financial markets as well as in the new views on how to resolve some of these problems might refer to the volumes by Donald and by Adams, Graham, and Von Pischke cited at the end of the paper.

[4] The various terms used in the literature to categorize financial markets include *institutional* and *noninstitutional, organized* and *unorganized, regulated* and *nonregulated, commercial* and *noncommericial, production* and *consumption,* and *formal* and *informal.* I feel more comfortable with the latter two terms and use the term *formal* to mean all financial transactions that are supervised, regulated, and monitored by some central financial or monetary authority. The term *informal finance* encompasses all other financial activities in an economy.

loans while nearby formal lenders were awash in defaults, and I marveled at the ability of informal finance to mobilize and allocate large amounts of voluntary savings, while banks attracted relatively few deposits.[5]

My amazement arises from the contrast in the types of people served by formal and informal finance along whit the differences in types of services provided. Formal finance typically involves large loans and deposits, secure collateral, relatively long-term financial instruments, and legal backing. Formal finance also services mostly individuals who are the créme de la créme but who are required to come to the financial institution to transact their bisiness. In contrast, informal finance frecuently involves small loans and deposits, commonly functions without collateral, typically deals with short term transactions, and often operates in the legal shadows. Many participants in the informal system are poor people, women, operators of small businesses, small farmers, and the landless--people who are often unable to obtain formal financial services. Unlike the formal financial system, transactions in informal finance usually occur at the doorstep of clients, at their place of work, or in popular markets. I am amazed that informal finance can provide these services to the people it does without choking on expenses and drowning in defaults. Like the aeronautical engineers who have analyzed bees and concluded they should not be able to fly, I am convinced that informal finance defies the laws of financial gravity.

Further, I am puzzled by the ability of informal finance to provide sustained financial services to large numbers of individuals who have been targets of temporary or sporadic formal credit programs. These formal credit efforts are usually staffed by educated people who receive extensive technical assistance from both donors and governments along with ample access to both subsidies and concessionary funds. Even with these advantages, formal rural credit efforts often founder, while informal finance, which enjoys none of these advantages, typically flourishes. Success in financial transactions appears to be inversely related to years of education of the participants, technical assistance received, access to concessionary funds, and extent of regulation! This raises two important questions: Why do formal agricultural credit programs so often fail? And, why do informal financial activities so often succeed? Space limitations oblige me to deal mainly with the latter question here.

Traditional Views About Informal Finance

Informal forms of lending--particularly moneylenders--are stereotyped as being evil in many cultures. Poets, prophets, playwrights, and politicians have pointed accusing fingers at informal lenders and questioned the comfort of their after-life since the beginning of recorded history. Individuals as diverse as Cicero, Shelley, Shakespeare, Marx, the Prophet Mohammed, and writers of the *Old Testament* have vented their spleens

[5] Tuck reports similar conditions in Senegal in the early 1980s.

on the supposed evils of money lending. Pejorative and emotive terms such as *monopolist, usurer, shylock, loan shark,* and *exploiter* color discussions of this topic. I know of no other area in development where anecdotal horror stories are told and retold so often to nurture traditional views (Nelson). For my tastes, too many discussions of informal lending include racial and ethnic undertones reflecting the dark side of human nature: e.g., biases against Jews in Europe, overseas Chinese in East Asia, Indians in East Africa, Ibos in West Africa, and people from the Middle East in Latin America. These biases also stem from the natural tendency to fear and dislike an activity, such as financial intermediation, that is poorly understood and, to some observers, mysterious (Hayak).

Until relatively recently, much of the research on informal finance was done in what was Colonial India or by sociologists and anthropologists. Studies by Darling and others in India in the early 1900s showed that informal lending provided most of the loans in rural areas and that the interest rates applied were often higher than those charged by banks in either India or the United Kingdom. Subsequent studies in India--especially the All-India-Rural Credit surveys carried out each decade since the early 1950s--set the agenda for much of the later research and policy dialogue on informal finance in other regions. This agenda was generally negative in tone and stressed documenting the relative importance of informal finance, the extent of monopoly profits in these transactions, how loans linked to other marketing activities boosted profits, and the extent to which informal lending was used to appropriate land pledged as collateral (e.g., Ghose, Wai).

I am uneasy with this stereotyping and with the associated research. Instead, I feel there are important lessons to be learned from more objective study of informal finance--lessons that will be overlooked as long as we insist on chasing bogeymen in research on informal finance. Taking a fresh look at informal finance should involve studying the services provided along with the associated techniques, practices, and technologies used. Careful analysis of informal finance may also provide clearer insights into the types of financial services individuals and firms find to be most useful.

Types of Informal Finance

Finance exists because of heterogeneity among firms and individuals and because of the specialization and trade that ensues from these differences. This, in turn, results in a variety of financial needs which are partly met by a multiplicity of informal arrangements. While the stereotyped moneylender receives most of the publicity, a large variety of other arrangements handle most informal financial transaction in LICs. Some of these arrangements are centuries old, while other systems of informal finance are constantly evolving as the contours of the society and the economy change. The kaleidoscope of arrangements defies simple classification, and it is unusual to find a substantial number of these arrangements that are identical--a testimony to the flexibility and

creativity involved in informal finance. For purposes of illustrating the variety found in these systems I briefly describe ten types of informal finance. Although I treat these ten types separately, it is common for them to overlap and also to be intertwined with other production or marketing activities (Sanderatne).

Sophisticated but Unregulated Institutions

In several countries, including the Dominican Republic, Guatemala, and India, sophisticated financial institutions exist that are informal only in the sense that they are not regulated. These institutions act like commercial banks and are often located in banklike offices that appeal to middle- and upper-class clients. They exist primarily to avoid taxes or regulations. In some cases they may be affiliated with banks through joint ownership or holding companies. Several recent studies suggest that these unregulated organizations charge reasonable interest rates and operate with modest transaction costs (Nayar, Vogel, Zinzer).

Moneylenders--Individuals who spend most of their time lending money--moneylenders--are significant sources of loans mainly in Asia. Typically, their loans are granted for short periods, are unsecured by collateral, and are extended to long-term clients. Most moneylenders operate on a small scale, extend loans mainly out of their own funds, and restrict lending to less than a hundred or so individuals. Moneylenders typically charge interest rate that are high relative to other lenders but extend loans quickly and impose few transaction costs on borrowers. These lenders operate in localized markets and often have highly personalized relationships with borrowers.

The main advantage moneylenders have over formal lenders is the comprehensive information they accumulate about their clients through day-to-day contact. Timberg and Aiyar found an extreme example of this when they asked an Indian moneylender how he decided to take on additional clients; he responded that he had never had a new client. Understandably, the proprietary nature of this information causes moneylenders, as well as other informal lenders who heavily rely on inside information, to be leery about sharing candid information about their operations with researchers (Chandavarkar).

Merchants--A closely related and much more common form of informal credit is provided by individuals who are primarily merchants but who also extend loans linked to the sale or purchase of commodities (Bardhan, Floro, Harriss, McLeod). Typically, lending is only a minor part of the merchant's activities, loans are repaid in relatively short periods of time, many of the loans carry no explicit interest charge, and the lender may adjust the price of the commodity involved in the transaction as compensation for the loan. Economies of scope are the main advantage that a merchant realizes in providing loans. Merchants can generally sell more fertilizer or purchase more rice, for example, if they also offer loans to their customers. Like the moneylender, merchants have the

advantage of possessing inexpensive information about the borrower that is accumulated through purchases and sales of commodities. Under normal conditions the volume of loans provided by merchants increases as commercialization expands.

Some itinerant peddlers also provide small short-term loans to customers. In the Philippines, peddlers--often called Bombaies--sell items as diverse as umbrellas, electric fans, cosmetics, and clothing door-to-door in rural areas. They often make their village rounds on a daily or weekly basis to sell goods, take orders, and collect installment payments on previous purchases. Fruin reported similar services provided in rural areas of Indonesia during the 1930s by "installment chinamen."

Pawnbrokers--Still another form of informal finance is pawning, one of the oldest forms of lending. Some pawnbrokers work full-time at this occupation, whereas others pursue it as a sideline to money lending or marketing. In several countries, Indonesia and Sri Lanka, for example, some pawnshops are affiliated with banks.

Distinctive features of pawnshops are that they typically make small loans for short periods and resolve the loan collateralization problem inexpensively by requiring borrowers to exchange collateral physically for loans (Lamberte). Unlike banks, moneylenders, and traders, pawnbrokers need almost no information about their borrowers unless they are wary about receiving stolen goods. The Pawnbroker realizes revenue from interest on loans and from the difference between loan amounts and sales receipts from items received as security on defaulted loans. Contrary to conventional wisdom, Bouman and Houtman argue that most pawnbrokers prefer to have individuals redeem the items they pawn, as the improves the chances of their continuing as clients.

Some individuals in the Philippines make their living primarily by conducting informal pawning operations combined with peddling items door-to-door that are not redeemed. These individuals may have loose working relationships with formal pawnshops or with relatively wealthy people who occasionally provide them operating capital. They may also combine their pawning activities with selling nonpawned goods door-to-door and offering installment arrangements on these sales (Adams and Sandoval).

Loan Brokers--Another type of informal finance is carried out by loan brokers who facilitate contacts among people with money to lend and borrowers by trading on inside information about potential clients. Typically, loans handled by brokers are relatively large and for a longer term than are most informal loans. Virtually anyone can enter the business who is able to assemble information about potential clients. Because borrowers of these brokered loans often do not qualify for additional bank credit, interest rates applied to these loans may be relatively high. As Larson points out, some of the lenders in Bolivia insist on collateral such as real estate before making a brokered loan. The broker is usually not a principal in

the transaction but merely arranges contacts between lenders and borrowers. Some brokers may also provide collection or guarantee services and thus become more like principals than agents.

A different form of loan broker operates widely in rural areas of Bangladesh. These brokers obtain loan application forms from banks, help illiterate people fill them out, obtain necessary signatures and guarantees, and also allocate bribes necessary to overcome barriers to borrowing (Maloney and Ahmed). The broker is commonly rewarded through a share of the bribe or a share of the loan and acts as a legal buffer between the payer and receiver of the bribe.

Landlords--Although the practice is less common now than previously, some landowners still provide their tenants with loans. The main reason for this is scope economies. These loans facilitate access to labor and entrepreneurial skills that might otherwise be difficult to employ or manage. Typically, landlord lending declines in realtive importance with land reform and with the expansion of other types of formal and informal finance (Sacay, Agabin, and Tonchoco).

A variant of this occurs when landowners who borrow money transfer to a lender usufruct rights over land, orchards, or fishing facilities for a time until loans are repaid. This arrangement is common in the highlands of Ecuador and among cacao farmers in Ghana (Adejeboye). It is also increasingly found in the Philippines, where farmers may pawn the title to some of their land and transfer use rights to the lender for a time to obtein relatively large loans to finance employment abroad by a family member.

Friends and Relatives--Perhaps the most common form of informal finance, both in terms of number and value of transactions, is loans from friends and relatives. In some countries these credits make up half or more of all informal loans. Many of these loans involve no interest or collateral, they may be large or small, and many have open-ended repayment arrangements. The most important feature of many of these loans is reciprocity: the expectation that the borrower is willing to provide a loan to the lender sometime in the future (Platteau and Abraham). In cases where the individuals involved have scant access to other forms of finance, the reciprocity may be an important way of managing uncertainty and risk through establishing and strengthening interpersonal ties.

Money Guards--Another from of informal finance is the money guard, a responsible person who agrees to safeguard cash for individuals. Graham and others report finding money guards in Niger, Maloney and Ahmed also found them in Bangladesh, and Bouman and Houtman report similar arrangements in India. Almost the entire reason for money guards is that they offer a secure place to deposit funds. In most cases these deposits earn no interest, although money guards may give depositors token favors or gifts. There are no restrictions on the uses money guards may make of deposited funds.

In some cases depositors feel guards are doing them a favor by holding their money, and the amount of money deposited by each individual is usually small.

Non-rotating Savings and Credit Groups

Another important form of informal finance is nonrotating savings and credit groups. These consist of individuals who either regularly or irregularly, deposit funds with a group leader (e.g., Begashaw; Maloney and Ahmed). In most cases these groups are formed spontaneously, but in Thailand a government agency--the Community Development Department--plays a role in organizing such groups. The main problem these groups resolve is the pooling of savings, and it is not uncommon for these mobilized funds to be deposited in banks. While these groups may collect funds regularly, they do not distribute them among members through any systematic rotation. These groups are part of a larger class of informal groups that pursue a variety of purposes ranging from conducting financial intermediation to taxing group members to improve public facilities.

Some groups periodically collect funds from members and then return the amounts deposited to savers at the end of a given period; these are essentially contractual savings programs. Instead of returning contributions to members, other groups use money collected as emergency loan funds. Group members are essentially building reciprocal credit possibilities through their deposits. In other cases, the funds collected may be used to invest in enterprises that are administered by the group. Some groups are managed by commission agents, while others are run by volunteer leaders. Various forms of these groups can be found in most low-income nations, but they are especially important in Africa and in Islamic countries.

Roscas--A more complicated form of group finance is called rotating savings and credit associations (ROSCAS). They are found in many LICs and have been extensively studied, especially by sociologists and anthropologists (Bouman). In a number of areas more individuals participate in ROSCAS than have dealings with formal financial institutions, and large amounts of money may be involved (Adams and Canavesi). Recent research by Schrieder in Cameroon suggested the volume of deposits moving through ROSCAS there may be larger than the amounts held in banks. In some countries, especially among ethnic minorities, ROSCAS are a primary way of raising funds to make large business investments (Barton, Wu).

These associations are particularly interesting because they explicitly pool savings and tie loans to deposits. ROSCAS also resolve the loan collateral and borrower information problems by enrolling only members who have mutual confidence in each other or by having organizers who guarantee the performance of individuals they enroll. Loan recovery is seldom a problem in ROSCAS because a defaulting member not only loses the opportunity to remain in the association but may also be shunned

and experience the loss of social and business ties that accompany membership (Velez-Ibanez).

It is surprising how often ROSCAS are found among employees of formal financial intermediaries. Many of the workers in the National Credit Union Federation in Chocabamba, Bolivia, for example, are members of ROSCAS (pasanakus). People working for the Development Finance Corportions in both Belize and St. Kitts?Nevis regularly participate in ROSCAS (syndicates and partners). Numerous employees of commercial banks and central banks in Belize and Bolivia are also ROSCA members. These associations likewise operate among employees of the Central Banks of the Dominican Republic (sans) and the Philippines (paluwagans). In 1987 there was even a ROSCA operating among employees of the International Monetary Fund in Washington, DC, all of whom had doctoral degrees in economics or finance!

The Case Against Exploitation

Critics most often cite exorbitant interest rates as the main justification for condeming informal finance. Cases of lenders charging 10 percent per day on loans, for example, are cited and then generalized as being representative of exploitation and proof of monopoly power. Also cited and generalized are horror stories about diabolical moneylenders or merchants who, in order to capture the borrower's collateral, extend loans to individuals whom lenders know will be unable to repay, debts that are inherited by the borrower's children, landlords who tie their tenants to land through debt at the company store, and merchants who link loans to repayment in kind and force borrowers to repay with products that are grossly underpriced (Basu, Bhaduri). These horror stories illustrate situations that are only possible when the lender exercises a large measure of monopoly power. Also, they report one-time operations that normally do not make economic sense for lenders who benefit from sustained relationships with their clients.

These blanket indictments, moreover, ignore the large number of informal loans made at modest interest rates, the multitude of loans made and repaid without the lender foreclosing on collateral, and the complexities involved in loans tied to marketing and production. They also ignore the extensive deposit mobilization that occurs in these markets, the multitude of informal loans made with no collateral involved, and the large number of people who pay high interest rates on their loans but realize even higher rates of return on investments made with borrowed funds. Critics also fail to mention that moneylenders may make only a few loans at extremely high interest rates, that these credits are often unsecured, and that borrowers paying the highest rates have low credit ratings. Critics also ignore inflation. In the mid-1980s informal lenders in Bolivia would have lost purchasing power on their loans if they had only charged 10 percent per week while inflation roared along at a rate of several thousand percent per year.

It is also important to remember that many of the loans with so called usurious interest rates are small and are for very short periods. It is common in Latin America, for example, for street vendors to borrow occasionally in the morning enough funds to cover their sales for the day and then to repay loans in the evening. A typical loan may be for only ten dollars and require repayment of eleven dollars, an annual interest rate of over 3,000 percent. At the same time, the loan may allow the vendor to realize daily earnings that are several times the value of the loan. It is unlikely that moralists would be upset with a merchant who each day sold the same kind of merchandise to a vendor but added a markup of 10 percent to the price of the good, a transaction that did not involve a loan.

At least three questions must be answered to establish whether lenders are taking undue advantage of borrowers: (1) What are a lender's opportunity costs of funds and the risks involved in lending? (2) Are most informal lenders in a position to extract monopoly profits? And (3) are credit transactions linked with marketing and production to enhance exploitation?

Opportunity Costs and Risk--Much has been asserted about the ubiquitous monopoly power of moneylenders, but little proof has been presented to support this allegation. Studies by Singh and Harriss of moneylenders in India, along with a similar study by Wilmington in the Sudan, show that moneylenders' interest rates are high because the opportunity costs of funds together with lending risks are high. These researchers argue that it is unreasonable to expect moneylenders to charge borrowers less than the rate of return lenders could realize on alternative investments and that many moneylenders have business alternatives that yield high marginal returns. The high interest rates in informal markets may largely indicate that funds are scarce and that at least some people realize high rates of return from using borrowed funds.

Christen makes the same point from the perspective of borrowers in Latin America. He argues that many managers of microenterprises borrow from moneylenders at high rates of interest because of the low transaction costs involved and the high quality and dependability of the informal financial services and also because high rates of return results from the use of borrowed funds. Many of these high return activities are also available to lenders and are further indicators of high opportunity costs of lending.

In addition, because of the seasonality of agricultural production, informal lenders may find it impossible to keep all of their money lent during the entire year. This forces them to charge higher interest rates during the time their money is lent to make up for periods when some of their loanable funds are idle.

Monopoly Profits--Because of the lack of barriers to entry, the large number of forms of finance, and the large number of people who are willing to enter markets where high rates of return are realized, it is difficult to see how informal lenders can regularly extract substantial monopoly profits. All of the many

forms of informal finance, as well as formal lenders, partially compete with each other. In addition, anyone with money or easily transferable resources can become a lender. Effectively, there are few barriers to entry into informal finance. Likewise, borrowers can compete with informal lenders through substitution of equity for debt, barter, and sale and repurchase of assets. For example, if farmers have been borrowing funds from moneylenders to pay cash rent on farm land, they can instead rent land on a share basis from landowners. Also, the reason people invented money is that it will substitute for so many other things, but the reverse is also true: many things are partial substitutes for money through barter. The conditions necessary to realize monopoly profits exist only with barriers to entry and a highly differentiated product, conditions seldom encountered in informal financial markets.

If traces of monopoly power exist in informal financial markets they can be moderated by expanding formal lending. To be fully effective, however, the expansion in formal finance must compete with those elements of the informal system that have little competition. An expansion of cheap formal loans that go largely to well-to-do individuals does not compete with informal lenders who are largely serving the poor (Gonzalez-Vega).

Loans Linked with Marketing--It is often difficult to establish clearly the charges that are applied to loans when the loan or the repayment are in Kind, as is often the case with loans linked to marketing. For example, a merchant in Sudan may agree to lend a farmer two sacks of millet and require the repayment of three sacks at harvest time in only two months. On a commodity basis, this amounts to a monthly interest rate of 25 percent or an annual rate of 300 percent. On a financial basis, however, the rate is much lower, even ignoring inflation. Usually, the market price of millet between harvests is significantly higher than the price during harvest. If the interharvest price ranged from 25 to 50 percent higher than harvest prices, the interest rate on the loan would range from 0 to 120 percent on an annual basis. When loan repayment is in Kind, the merchant assumes all of the price risk, something that is of additional value to the borrower. If a merchant in fact consistently realizes a monopoly profit on his millet-credit transactions, the cause may be imperfections in the millet market rather than monopoly power exercised in credit transactions. The merchant may own the only truck in town that is needed to haul millet to central markets, but it is less likely that the merchant will be the only person in the area who has funds or resources to lend. If monopoly power lies in other markets linked to informal finance, that power will not be directly affected by finance activities or their regulation.

While I have not systematically studied linked credit transactions, I have talked with a large number of merchants in various countries who provide loans to some of their customers to facilitate purchases or sales of goods. I have yet to find a merchant who would not prefer cash transactions over those involving credit. This suggests to me that most

merchants view lending as a necessary nuisance rather than as a way to sweat additional profits out of their clients.

Moneylenders as "Hospitals"

Some so-called malignant informal lenders are mainly involved in providing small, short-term loans that are seldom backed by collateral and that are made to individuals who often suffer economic reverses. It is this part of informal finance that is a lightning rod for criticism of informal finance in general.

Instead of stereotyping as evil the informal lenders who serve this difficult set of clients, it may be more useful to think of them metaphorically as hospitals. Many of the patients who go there are physically (financially) stressed. They lack sufficient knowledge (funds) to heal themselves. As a result of their visit, some of these patients are cured and never return to the hospital. The health of others is improved by their visit, but some of them must return periodically for additional treatments (loans) to sustain their well-being. A few patients may perish (default) after coming to the hospital because their illnesses were too far advanced, they had afflictions that could not be treated by medicine (loans), or they refused to follow prudent health practices (were inefficient or unlucky managers).

Continuing the metaphor, hospitals are the most expensive form of medical treatment (charge the highest interest rates) because they mostly handle patients who are seriously ill (have the lowest credit ratings). In times of plague or natural disaster, a higher proportion of the patients (borrowers) coming to the hospitals may expire (default) because the hospital staff cannot give them sufficient attention (loans) or because they cannot extend the treatment over a long enough period of time (roll over the debt). More of the patients may also pass away (default) because they arrive at the hospital in worse shape than is true in normal times. In addition, doctors (informal lenders) will make more mistakes in their treatments (loans) because they are also stressed by the disaster. Since hospital employees are susceptible to many of the ills suffered by their patients, some of the employees (informal lenders) contact diseases from their patients and became seriously ill and even expire (go bankrupt).

Blaming moneylenders for the financial difficulties encountered by a few of their borrowers is as illogical as condening hospitals because they treat people who are ill and because some of their patients pass away.

Lessons from Informal Finance

Informal finance persists and often flourishes because it resolves important problems that are handled poorly or not at all by most formal financial systems. I see at least six important lessons in this.

Types of Services Provided--The variety of informal financial arrangements is evidence of the broad range of financial services demanded by people in low-income countries. It is surprising how

different these services are from those emphasized in traditional formal credit programs. Deposits, small loans, and short-term loans make up a large majority of informal financial transactions--services that are almost always absent in traditional agricultural credit programs. I conclude that many traditional credit programs may be providing the wrong mix of financial services.

Process Based on Discipline--Informal finance almost involves participants in orderly processes that result in increasingly disciplined behavior. Informal lenders must discipline themselves to save to accumulate funds to lend. They must further discipline themselves to collect sufficient information about prospective borrowers so their loans can be made on the basis of creditworthiness. Informal lenders typically learn to judge creditworthiness and mobilize deposits over many years and only survive in the business if they are successful in developing these skills. Because most informal lenders have equity interest in their loans, they look at credit as a privilege, not a right, and view lending as a seriuos transaction rather than as a game of passing out favors.[6]

Informal borrowers also learn discipline as they attempt to establish and expand their creditworthiness in the eyes of informal lenders or group members. Borrowers of informal loans must earn the privilege of borrowing through disciplined steps that may include saving before borrowing, repaying small loan before receiving larger loans, and always repaying obligations to sustain access to informal finance. The products of increased discipline are strong and dependable working relationships between lenders and borrowers. These working relationships are the foundation of stable, reliable, and sustainable financial markets.

All too often, traditional agricultural lending is a hurried event that ignores this important process of learning, testing, and discipline building. I conclude that formal lenders ought to spend more time learning how to make loans on the basis of creditworthiness and that more attention must be given to helping borrowers systematically build their creditworthiness before showering them with loans.

Savings--The large amounts of savings that surface in informal financial markets are an indication of substantial propensities to save voluntarily and also show the miserable failure of most formal financial systems to provide attractive deposit services. Rural banks and cooperatives that do not accept deposits, negative real rates of interest on many deposits, and cheap rediscounting facilities in most central banks have resulted in few formal deposits being mobilized. Although formal financial systems should have a natural comparative advantage in mobilizing voluntary deposits, they have been largely designed to dispense cheap funds

[6] An informal lender, for example, would never think of passing out hundreds of loans in a day on an ad hoc basis as has been done in India through highly politicized "loan melas" (loan fairs). Nor would an informal lender ever consider dropping off hundreds of loans in remote villages via helicopters as was done in Nicaragua a few years ago.

provided by government and donors. I conclude that informal finance works well because it depends on voluntary savings (inside money), while formal finance often fails because it heavily relies on governments or donors for funds (outside money).

Reciprocity--Many forms of informal finance involve reciprocity: the direct typing of loans to deposits or one person lending to another with the understanding--ofttimes implied rather than explicitly stated--that the lender may someday need to reverse roles. These unutilized credit reserves are especially important for low-income people who face uncertain conditions. Seldom do traditional formal credit programs provide lines of credit or more than just a single loan during a given period--they so not provide emergency credit. I conclude that formal finance would be much more useful to many people in LICs if credit reserves were more readily available.

Financial Innovations--Informal finance is peppered with innovations that reduce transaction costs, especially for depositors and borrowers. It is surprising how quickly informal finance can innovate to accommodate changing conditions such as inflation, economic prosperity, or economic downturns. Flexibility and suppleness are hallmarks of informal finance. In contrast, much of the innovative energy in formal financial markets is directed at regulation avoidance, and formal finance is often too brittle and rigid to respond effectively when economic conditions change.

I conclude from this that managers of formal financial institutions ought to be more observant of innovations and changes in informal finance and try to emulate many of these innovations.

Transaction Costs--A major achievement of informal finance is keeping the transaction costs of borrowers and savers low by bringing financial services to places and at times that are convenient to clients. In contrast, formal finance focuses mainly on reducing the transaction costs of the financial intermediary with little concern given to how this affects depositors and borrowers. With rare exceptions, clients of formal financial intermediaries must make deposits and seek loans on the premises of the intermediary at times that may or may not be convenient to clients.

The sharp differences in the distribution of transaction costs among participants in formal and informal financial markets are excellent proxies for the basic orientation of principal actors in these two markets. Formal intermediaries are mainly concerned with cultivating their major sources of funds: government officials, central bank employees, and donor employees; borrowers or depositors of small amounts are often treated as if they were pests. Informal intermediaries, in contrast, are almost entirely concerned about sustaining quality relationships with their borrowers or depositors.

I conclude from this that formal lenders must pay much more attention to reducing the transaction costs of borrowers and depositors and that they will likely not do this until large amounts of outside money are no longer available to them.

Concluding Remarks

Sustainable financial markets that operate efficiently and equitably are vital ingredients in rural development. The results of many formal agricultural credit programs in LICs over the past 30 years have been disappointing, and informal finance appears to be doing a better job of servicing the financial needs of many people in these countries than do these formal efforts. I don't want to be misinterpreted as arguing that formal financial arrangements are unnecessary and that informal finance is sufficient to support development; informal lenders are not the equivalent of the "noble savage." An efficient formal system is clearly necessary to intermediate over large distances, to efficiently manage large amounts of deposits, to make large loans, and to make long-term loans.

My main contention is that instead of trying to abolish informal financial arrangements, policy makers would be better advised to learn from them. Studying these markets will help to clarify the financial services that informal finance is providing more efficiently than formal intermediaries and may also uncover practices that could be adopted by banks and cooperative that are providing financial services. Giving three cheers for the informal lender is far more in order than trying to drive them out of business.

References

Adams, Dale W. and Marie L. Canavesi de Sahonero. "Rotating Savings Credit Associations in Bolivia." Economics and Sociology Occasional Paper No. 1417. Department of Agricultural Economics and Rural Sociology, The Ohio State University, May 12, 1988. 18 p.

Adams, Dale W. and others. *Undermining Rural Development with Cheap Credit.* Boulder, CO: Westview Press, 1984.

Adams, Dale W. and Virginia Nazarea-Sandoval. "Informal Finance in the Philippines." Economics and Sociology occasional Paper No. 1570. Department of Agricultural Economics and Rural Sociology, The Ohio State University, March 24, 1989. 57 p.

Adegboye, R.O. "Procuring Loans by Pledging Cocoa Trees." *Journal of the Geographical Association of Nigeria* 12(1969):

Bardhan, Prahab K. "Interlocked Factor Markets and Agrarian Development: A Review of Issues." *Oxford Economic Papers* 32(1980): 82-98.

Barton, Clifton G. "Credit and Commercial Control: Strategies and Methods of Chinese Businessmen in South Vietnam." Unpublished Ph.D. dissertation, Department of Anthropology, Cornell University, 1977, 392 p.

Basu, K., *The Less Developed Economy.* Oxford: Blackwells, 1984.

Begashaw, Girma. "The Economic Role of traditional Savings and Credit Institutions in Ethiopia." *Savings and Development* 4(1978): 249-262.

Bhaduri, Amit. "On The Formation of Usurious Interest Rates in Backward Agriculture." *Cambridge Journal of Economics* 1(1977): 341-352.

Bouman, F.J.A. "Indigenous Savings and Credit Societies in the Third World: A Message." *Savings and Development* 1(1977): 181-220.

Bouman, F.J.A.and R. Houtman. "Pawnbroking as an Instrument of Rural Banking in the Third World." *Economic Development and Cultural Change* 37(1988):69-89.

Chandavarkar, Anand G. "The Informal Financial Sector in Developing Contries: Analysis, Evidence, and Policy Implications." Unpublished paper, International Monetary Fund, February 13, 1986. 40 p.

Christen, Robert P. " What Microenterprise Credit Programs Can Learn from the Moneylenders." Unpublished paper, ACCION International, San Jose, Costa Rica, 1988. 26 p.

Darling, M. L. *The Punjab Peasant in Prosperity and Debt*. London: Oxford University Press, 1925.

Donald, Gordon. *Credit for Small Farmers in Developing Countries*. Boulder, CO: Westview Press, 1976.

Floro, Sagrario Lim. "Credit Relations and Market Interlinkage in Phillippine Agriculture." Unpublished Ph.D. dissertation, Stanford University, 1987. 373 p.

Fruin, Th. A. " Popular and Rural Credit in the Netherlands Indies." *Bulletin of the Colonial Institute of Amsterdam* 1(1937): 106-115.

Ghose, A. K. "The Formation of Usurious Interest Rates." *Cambridge Journal of Economics* 4(1980): 169-172.

Gonzalez-Vega, Claudio. "Cheap Agricultural Credit: Redistribution in Reverse." in *Undermining Rural Development with Cheap Credit*, edited by Dale W Adams and others. Boulder, CO: Westview Press, 1984, pp. 120-132.

Graham, Douglas H. and others."Informal Finance in Rural Niger: Scope, Magnitude and Organization." Economics and Sociology Occasional Paper No. 1472. Department of Agricultural Economics and Rural Sociology, The Ohio State University, May 1988. 22 p.

Harriss, Barbara. "Money and Commodities: Their Interaction in a Rural Indian Setting." in *Rural Financial Markets in Developing Countries*, edited by J.D. von Pischke, Dale W Adams, and Gordon Donald. The John Hopkins University Press: Baltimore and London, 1983, pp. 233-241.

Hayak, F. A. *The Fatal Conceit: The errors of Socialism*, Chicago: University of Chicago Press, 1989.

Lamberte, Mario B. "An Analysis of the Role of Pawnshops in the Financial System." Working Paper Series No. 88-04, Phi;ippine Institute for Development Studies, Makati, Philippines, February 1988, 36p.

Larson, Donald W. and Rene Urquidi. "Competitiveness of Informal Financial Markets in Bolivia." Economics and Sociology Occasional Paper No. 1426. Department of Agricultural Economics and Rural Sociology, Ohio State University, December 31, 1987, 22p.

McLeod, Ross. "Case Studies of Small Business Financing in Indonesia." Working Paper No. 101. Australian National University, May 1984. 41 p.

Maloney, Clarence and A.B. Sharfuddin Ahmed. *Rural Savings and Credit in Bangladesh*. Dhaka: The University Press Ltd., 1988.

Nayar, C.P.S. " Finance Corporations: An Informal Financial Intermediary in India." *Savings and Development* 6(1982): 15-52.

Nelson, Benjamin N. *The Idea of Usury, From Tribal Brotherhood to Universal Otherhood*. Princeton, NJ: Princeton University Press, 1942.

Platteau, Jean-Philippe and Anita Abraham. "An Inquiry into Quasi-Credit Contracts: The Role of Reciprocal Credit and Interlinked Deals in Small Scale Fishing Communities." *The Journal of Development Studies* 23(1987):461-490.

Sacay, Orlando J., Meliza H. Agabin, and Chita Irene Tonchoco. *Small Farmer Credit Dilemma*. Manila: Technical Board on Agricultural Credit, 1985.

Sanderatne, Nimal. "A Profile of the Informal Rural Credit Market in the Mid-Seventies." *Staff Studies*. Central Bank of Ceylon, 11(1981): 1-18.

Schrieder, Gertrud. "Informal Financial Groups in Cameroon: Motivation, Organization and Linkages." Unpublished Masters thesis, Department of Agricultural Economics and Rural Sociology, The Ohio State University, 1989.

Seibel, Hans Dieter and M. T. Marx. *Dual Financial Markets in Africa.* Saarbrucken: Breintenbach, 1987.

Timberg, Thomas A. and C.V. Aiyar. "Informal Credit Markets in India." *Economic Development and Cultural Change* 33(1984): 43-59.

Tuck, Laura. "Financial Markets in Rural Senegal." Chapter 5 in *The Political Economicy of Risk and Choice in Senegal*, edited by Mark Gersovitz and John Waterbury. Totowa, New Jersey: Frank Cass and Co., 1987. pp.74-89 and 160-187.

Velez-Ibanez, Carlos G. *Bonds of Mutual Trust: The Cultural Systems of Rotating Credit Associations Among Urban Mexicans and Chicanos.* New Brunswick, NJ: Rutgers University Press, 1983.

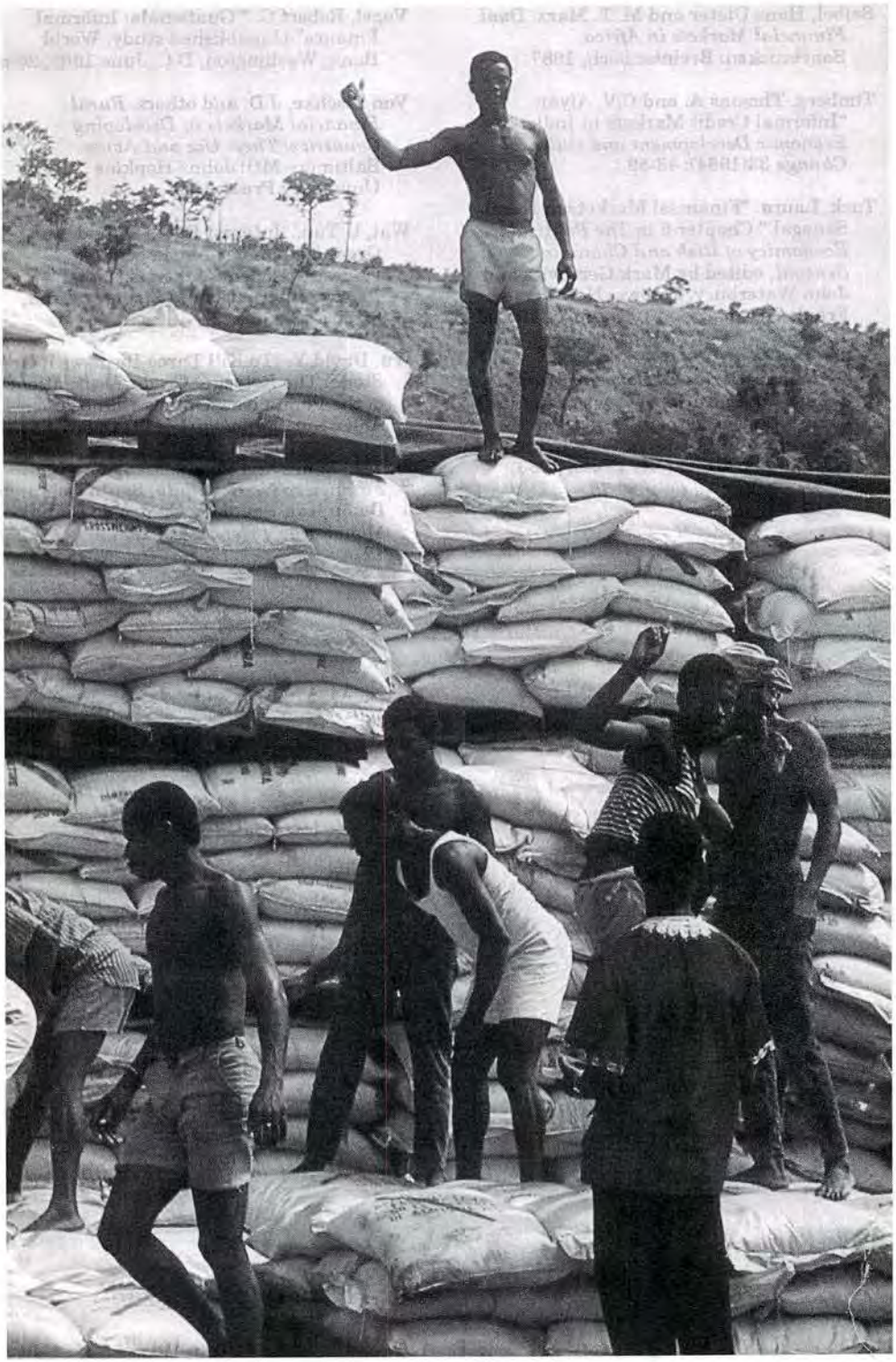
Vogel, Robert C. " Guatemala: Informal Finance" Unpublished study, World Bank, Washington, D.C, June 1988, 26 p.

Von Pischke, J.D. and others. *Rural Financial Markets in Developing Countries: Their Use and Abuse.* Baltimore MD: Johns Hopkins University Press, 1983.

Wai, U Tun. "Interest Rates Outside the Organized Money Markets of Undesdeveloped Countries." *Staff Papers.* International Monetary Fund, 6(1957-58): 80-142.

Wu, David Y. "To Kill Three Birds with One Stone: The Rotating Credit Associations of the Papua New Guinea Chinese." *American Ethnologist* 1(1974): 565-583.

Zinzer, James and others. *Mercado Financiero No Regulado.* Santo Domingo, Dominican Republic: Centro de Estudios Monetarios y Bancarios, 1986.



A Fertilizer Supply Strategy for Sub-Saharan Africa

L.B. Williams and J.J. Schultz *

Introduction

Given good genetic plant material, sound agronomic practices, favorable climatic conditions, the level of soil fertility become the major yield-determining factor for farmers worldwide.

Throughout Africa, including Ghana, low-fertility soils are a major constraint to achieving high yields with either native or improved plant varieties even when sufficient water is available (Nye and Greenland, 1960). For example, to achieve a 6-tonne yield of grain per hectare for maize, a basic food crop in Ghana and much of Africa, requires almost 300 kg of basic nutrients ($N + P_2O_5 + K_2O$), not to mention secondary nutrients such as magnesium and sulfur, which may also be needed (**Table 1**). The use of fertilizer to increase, and maintain, the fertility of the fragile and intensively cultivated African soils is extremely important if one expects to achieve and maintain high yields. The effective supply and efficient use of fertilizers are essential in that fertilizer represents the major cash cost of production for most African farmers, often exceeding 50% of the farmer's out-of-pocket cash expenses.

This paper will suggest some ways in which Ghana and most other African countries could provide these needed fertilizers in a cost-effective manner.

How Much Fertilizer is Needed?

Sub-Saharan Africa accounts for about 9% of the world's population yet uses less than 1% of the world's fertilizer. Furthermore, the population growth in the region at about 3% annually, is among the world's highest.

Current fertilizer consumption in sub-Saharan Africa amounts to only about 7 kg of nutrients ($N + P_2O_5 + K_2O$) per hectare of arable land or about 1.1 million tonnes annually (**Figure 1**) (FAO, 1988). For comparison, Asia averages about 91

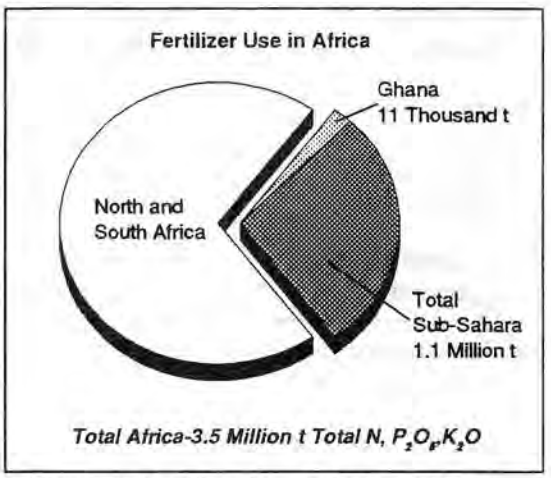


Figure 1. Fertilizer Use in Africa, 1987/88 (tonnes of nutrients). Source: FAO/FIAC Meeting, Rome, April 1989.

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Table 1. Approximate Uptake of Plant Nutrients for Selected Food Crops

Crop	Yield (mt/ha)	Nutrient Removal N	P_2O_5	K_2O (kg/ha)	MgO	S	Total
Cereals							
Maize	6	120	50	120	40	25	355
Rice	6	100	50	160	20	10	340
Sorghum	4	120	40	100	30	15	305
Wheat	6	170	75	175	30	30	480
Roots							
Cassava	40	150	70	350	40	20	630
Potato (white)	40	175	80	310	40	20	625
Vegetables							
Beans (green)	15	130	40	160	30	-	360
Onions and garlic	35	120	50	160	15	20	365
Tomato	50	140	65	190	25	30	450
Pulses (dry grain)							
Bean	2.4	155	50	120	20	25	370
Pea	2.0	125	35	80	15	-	255
Pigeon pea	1.5	70	10	55	10	5	150
Fruits							
Banana	40	250	60	1,000	140	30	1,480
Citrus	30	270	60	350	40	30	750
Oil Crops							
Groundnuts	2	170	30	110	20	15	345
Soybean	3	220	40	170	40	20	490
Stimulants							
Cocoa	1	40	15	90	10	-	155
Coffee	1.5	120	30	130	30	20	330
Tobacco	2	130	40	240	25	10	445
Other Plantation Crops							
Sygarcane	100	130	90	340	80	60	700

Source: Potash and Phosphate Institute (PPI), 1988.

kg/ha, while the United States and Western Europe average about 92 kg/ha and 231 kg/ha, respectively (**Figure 2**). Thus, it would not be unreasonable to suggest that, on average, at least a sevenfold growth in fertilizer consumption (to about 50 kg/ha) would be appropriate for the sub-Saharan region to provide the level of fertilization that is needed and could be used effectively. This would translate to an additional 6.6 million tonnes of nutrients per year over and above the approximately 1.1 million tonnes currently being used annually, bringing the total to nearly 8 million tonnes annually.

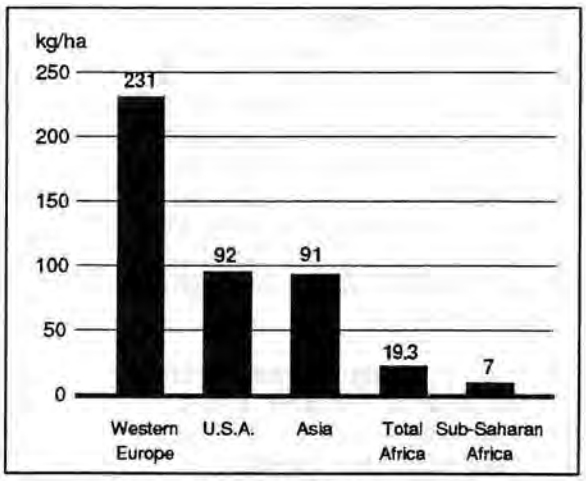

Figure 2. Fertilizer Nutrient Consumption Per Hectare of Arable Land, 1986. Source: FAO, 1988.

With specific reference to Ghana's approximately 1.7 million ha of cropped area, an average use of 50 kg of nutrients/ha would amount to about 85,000 tonnes of nutrients annually or nearly 200,000 tpy of total fertilizer material. During the 1980s, actual fertilizer use in Ghana averaged only about 16,000 tonnes of nutrients annually (about 40,000 tonnes of product) or about one-fifth of what would be considered a realistic initial goal (**Table 2**).

Thus, in Ghana as well as within the entire sub-Saharan region, there is sufficient fertilizer demand potential to support the placement of a number of fertilizer supply systems. The development of these supply systems, however, must be carefully synchronized with the actual growth in fertilizer demand; otherwise, they may impose an even greater economic hardship on the region. Suggestions for the stepwise development of a cost-effective fertilizer supply system are discussed later.

Table 2. Fertilizer Consumption in Ghana for the Period 1979/80-1987/88, tonnes

Nutrient tonnes	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
N	8,400	5,000	13,000	12,500	11,000	5,000	5,000	4,100	5,100
P_2O_5	5,900	2,000	8,000	5,600	7,000	1,400	4,300	2,000	2,700
K_2O	4,200	5,000	8,000	9,000	3,400	2,000	3,200	1,500	3,100
Total	18,500	12,000	29,000	27,100	21,400	8,400	12,500	7,600	10,900

Source: FAO, 1988. Data for 1987/88 From FAO/FIAC Meeting, Rome, April 1989.

How Can These Fertilizers Be Supplied?

In formulating an effective fertilizer supply scheme, it is important to understand and respect the unique nature of industrially produced chemical fertilizer materials. The uniqueness of chemical fertilizers stems from several factors including the following.

1. The performance, and therefore the value of fertilizer, is not guaranteed; instead, it is highly dependent upon timely availability, crop variety, management practices, and climatic conditions.
2. Fertilizers are available in an often confusing number of different nutrient combinations, sources, and concentrations.
3. Fertilizers generally are relatively spophisticated water-soluble chemicals and therefore require care in handling and storage to preserve their quality and usefulness.
4. Fertilizers are bulky; thus, considerable cost accrues for transportation and storage.
5. Because timely delivery and application by the farmer are of key importance, large and costly inventories at all levels in the supply system are often needed to minimize risk of shortages.
6. Fertilizers are often perceived to have low value although they represent a major cash cost input in developing-country agriculture.
7. Substantial recurring amounts of foreign exchange are needed to sustain a reliable fertilizer supply system, be it based on imports or local production.

Each of these factors must be considered in determining the most appropriate method for supplying the needed fertilizers. At the outset, the task of supplying fertilizer may seem to be quite simple; however, the task can, and often does, founder because of a lack of knowledge and awareness on the one hand and ineffective leadership, management, and policy support on the other. Knowledge, skilled leadership and management, and favorable government policy support are the essential elements for the smooth working of any type of developing-country fertilizer supply system, be it a basic scheme of importation or a more complex scheme involving the development of indigenous fertilizer resources (Williams, 1988).

A Look at the Options

Basic Production Units--Basic fertilizer production units are costly to construct and operate (Schults and Parish, 1989). Therefore, they must be relatively large in scale (typically 300,000 to 500,000 tpy product) and must be operated at high capacity utilization with favorable pricing to remain economic. The fixed capital investment required for a 500,000-tpy urea facility or a 300,000-tpy diammonium phosphate (DAP) plant may often exceed $300 million depending upon a number of site-specific factors (Tables 3 and 4). In such plants, the recovery of the fixed capital investment, including interest, represents the most costly component of the total production cost. As a result, the unsubsidized factory-gate cost of production in these facilities is often much higher than the prevailing international f.o.b. prices for such materials. For example, in the estimates shown in **Tables 3** and **4** for new installations, the factory-gate production cost of bagged urea is about US $228/tonne compared with a 1988 average

Table 3. Capital Investment and Production Cost Estimate-Urea[a]

Capital Investment[b]	Foreign Currency (US $ x 1 million)	Local Currency	Total
Fixed capital	252	108	360
Working capital	12	12	24
Total	264	120	384

Production Cost[b]	Cost, US$/t Urea Foreign Currency	Total[c]
Variable		
Natural gas--7 mm Kcal/t urea (28 million Btu/t at US $4.0/million Kcal (US $1.0/ million Btu	7.0	28.0
Catalyst, chemicals, and supplies-- US $4.0/t urea	3.2	4.0
Bags	5.0	10.0
Contract labor--US $1.5/t urea	0.0	1.5
Subtotal	15.2	43.5
Fixed		
Labor (operating and maintenance)-- US $3.0 million/year	0.0	6.6
Administration and general overhead-- 50% of labor	0.3	3.3
Maintenance materials--3% of fixed capital	21.3	23.7
Insurance and taxes--1% of fixed capital	0.0	7.9
Fixed capital recovery--17.1% of fixed capital	94.6	135.3
Interest on working capital--15% annual rate	4.0	7.9
Subtotal	120.2	184.7
Total (Factory gate, bagged)		
With fixed capital recovery	135.4	228.2
Without fixed capital recovery	40.8	92.9

[a] Basis for estimate: (1) Grass-roots complex in developing country location, (2) 1,000-tpd ammonia plant and 1,725-tpd urea plant, (3) 80% capacity utilization (455,000 tpy urea), and (4) fixed capital recovery based on 15 years and 15% annual interest rate.

[b] U.S. dollar equivalent, mid-1987 basis.

[c] Foreign currency cost plus local currency cost equals total cost.

Table 4. Capital Investment and Production Cost Estimate-plant DAP[a]

Capital Investment[b]	Foreign Currency (US $ x 1 million)	Local Currency	Total
Fixed capital	140	60	200
Working capital	14	14	28
Total	154	74	228

Production Cost[b]	Cost, US $/t DAP Foreign Currency	Total[c]
Variable		
Phosphate rock (local source)--1.60 /t DAP at US $35/t	14.0	56.0
Sulfur (imported)--0.45 t/t DAP at US $150/t	60.8	67.5
Ammonia (imported)--0.23 t/t DAP at US $160/t	33.1	36.8
Catalyst, chemicals, and supplies--US $5.0/t DAP	4.0	5.0
Bags	5.0	10.0
Contract labor--US $1.5/t DAP	0.0	1.5
Subtotal	116.9	176.8
Fixed		
Labor (operating and maintenance)--US $2.5 million/year	0.0	7.4
Administration and general overhead--50% of labor	0.4	3.7
Maintenance materials--3% of fixed capital	16.0	17.8
Insurance and taxes--1% of fixed capital	0.0	5.9
Fixed capital recovery--17.1% of fixed capital	70.8	101.2
Interest on working capital--15% annual rate	6.2	12.4
Subtotal	93.4	148.4
Total (Factory gate, bagged)		
With fixed capital recovery	210.3	325.2
Without fixed capital recovery	139.5	224.0

[a] Basis for estimate: (1) Grass-roots complex in developing country location, (2) 600-tpd (P_2O_5) phosphoric acid plant, (3) 1,800-tpd sulfuric acid plant, (4) 1,250-tpd DAP plant, (5) 80% capacity utilization (338,000 tpy DAP), and (6) fixed capital recovery based on 15 years and 15% annual interest rate.

[b] U.S. dollar equivalent, mid-1987 basis.

[c] Foreign currency cost plus local currency cost equals total cost.

international f.o.b. price of about US $150/tonne for bagged product. Likewise, the production cost of bagged DAP is estimated at about US $325/tonne compared with about a US $220/tonne (1988 average) international f.o.b. price for bagged product. It is also important to note that the foreign currency cost of production often exceeds 50% of the total production cost in such new facilities.

Because the required capacity of these basic production units is so large compared with local consumption (for example, only one of the 40 sub-Saharan countries (Nigeria) consumed more than 250,000 tonnes of fertilizer in 1988), it is impossible to economically justify the construction of such facilities in most sub-Saharan Africa countries. The new urea production complex in Nigeria, sub-Saharan Africa's largest fertilizer consumer, depends heavily on the international export market as an outlet for a major portion of its product. The current international selling price for the Nigerian urea, however, is undoubtly well below the full, unsubsidized cost of production even though the facility is based on the exploitation of Nigeria's extensive natural gas reserves. It is interesting to note, as strikingly shown in **Figure 3,** that the price of natural gas has only a minor impact on the total production cost of urea in a new facility; in such a facility, the fixed cost burden is disproportionally high (about 80% of the total production cost), primarily because of the high fixed capital investment.

The whole of Africa is endowed with numerous phosphate ore deposits, a potential source of phosphate fertilizer. With the exception of the export-oriented facilities in Togo, Senegal, Morocco, and Tunisia, none of these deposits have been commercially developed on a large scale (McClellan and Notholt, 1986).

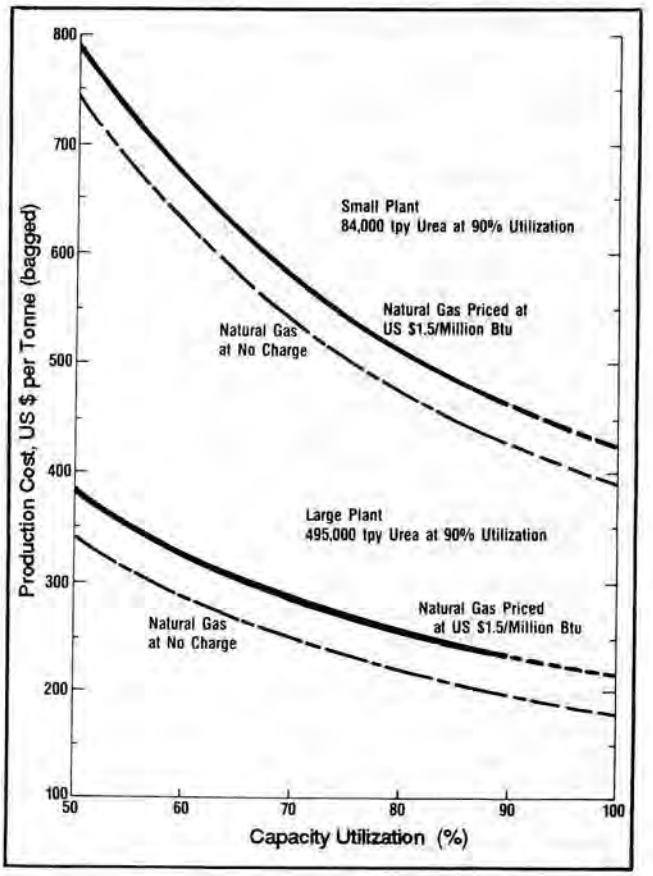

Figure 3. Effect of Capacity Utilization and Gas Price on Factory-Gate Production Cost of Urea--New Facility. Source: Schultz and Parish, 1989.

This lack of development is due to a number of factors. While some of these deposits are small and too low in quality for commercial development, the most important constraint to development is the lack of a reliable domestic market for the phosphate to justify the investment for development and the cost of operation.

Importation of Finished Products-Where markets for fertilizers are small, African countries, by developing sound procurement practices, can benefit from the more favorable economics of the world-scale basic production units located in Europe, the United States, North Africa, and elsewhere.

In general, the cost of production in the existing world-scale export-oriented fertilizer units is relatively low for several reasons. Most of these plants are strategically located with respect to extensive and high-quality raw material resources; they are operated at a high capacity utilization; and because the plants are quite old (but well maintained) and mostly depreciated, they have a relatively low fixed capital cost burden per tonne of product. In addition to these factors, strong competition among these basic producers for market share tends to keep international prices depressed.

Because of these relatively low basic production costs (and therefore f.o.b. prices) together with the existing favorable ocean shipping channels and rates to many African ports, the potential exists for very favorable landed (c.i.f.) costs for improved fertilizers in Ghana and at most other African ports (Wiersholm, 1989).

Saving Through Improvements in Procurement--The landed cost of fertilizer can often be decreased by about 20%-40% through relatively simple improvements in the management and operation of the procurement system. The following are some of the key elements of a streamlined and cost-effective procurement system:

1. Realistic demand forecasts based on (a) using a minimum number of different fertilizer grades that are widely available in the international market and by selecting those fertilizer types that will meet the needs of the farmers and the country, (b) constant field verification of fertilizer use patterns, and (c) consolidation of delivery schedules for each major consuming region.

   The selection of the appropriate fertilizer type(s) and the translation of these recommendations into realistic demand forecasts require the agronomist and the forecaster to be keenly aware of the commercial aspects of fertilizer supply and use.

2. Consolidation of annual fertilizer requirements into large orders (8,000-10,000 tonnes) to obtain favorable f.o.b. prices and long-distance ocean/shipping charter rates.

3. Unrestricted and timely availability of foreign exchange for fertilizer procurement.

4. Sufficient in-country fertilizer inventories to minimize "panic" purchases during peak periods of international trade (high f.o.b. prices) and thus take advantage of

favorable variations in international prices and charter rates.

5. A streamlined administrative approval procedure to allow the procurement unit to rapidly respond to unexpected changes in the international supply/demand/pricing structure.

In Ghana, as well as in many other developing countries, fertilizers have been supplied primarily through donor support on an ad-hoc basis. Thus, in most cases a systematic approach to the procurement of imported fertilizers has not been developed. As a result, a realistic cost base for imported fertilizers is often lacking. Nevertheless, the following tabulation (**Table 5**) illustrates quite clearly the cost benefits that could accrue through the implementation of a well-managed and fully integrated procurement unit compared with the current ad-hoc or "standard" practice. Such savings can be transferred directly to the farmer, thus markedly improving his incentive to use fertilizer.

The landlocked countries of Africa share a common problem of long distance, across-border, inland transport (**Figure 4**). This problem, while independent of the basic source of supply, can be partially alleviated through the implementation of a well-planned fertilizer procurement system.

Savings Through Local Bagging Operations--Importation of bagged fertilizers is recommended when the fertilizer supply system is in the early stages of development and

Table 5. Potential Savings Due to a Well-Managed and Integrated Fertilizer Procurement Unit

Procurement Activity	Potential Savings Over Current Practice (US $/tonne fertilizer)
1. Effective demand forecasting to optimize (minimize) in-country inventories	20-50
2. Purchase of readily available "standard" grades of fertilizer	10-50
3. Consolidation of orders into large lots to obtain favorable f.o.b. prices	5-10
4. Use of charter ocean shipping terms for large lots of fertilizer instead of more costly liner terms normally used for small lots	20-40
5. Timely allocation of foreign exchange and streamlined administrative approval procedures	5-10
Total Potential Savings	**60-160**

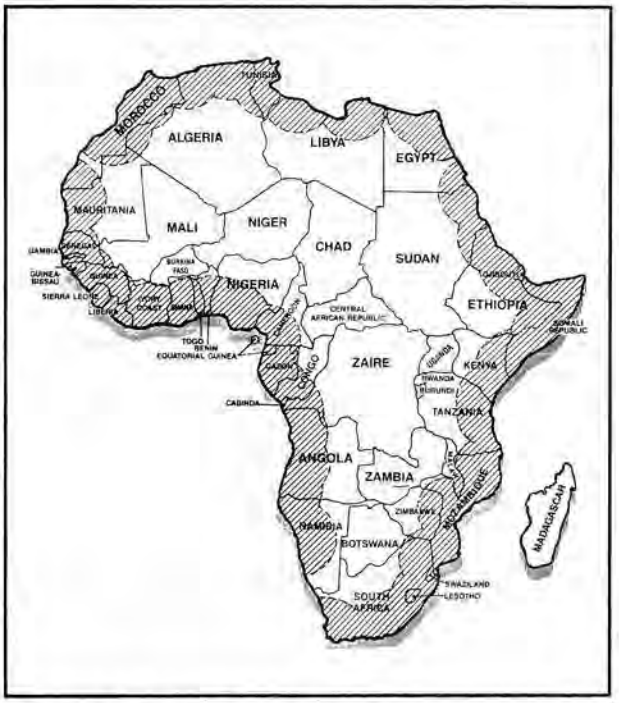

Figure 4. The Scale of the Transport Problem (area within 500 km of African ports).

demand is small. Bagged products are easy to handle and offer considerable felxibility in ocean shipping, port handling, and in-country distribution. Almost without exception in Africa, fertilizer is delivered to the farm-level retail outlet in bags (usually 50-kg units); thus bagging is an essential part of the delivery system. As demand grows, however, local bagging should be considered. The question then is: Where is the most cost-effective location to carry out the bagging operation?

With large tonnages it is often more cost effective to ship the fertilizer cargo in bulk to the receiving port to avoid the relatively high cost of bagging and loading to ship in the developed country (point of manufacture). With such a transport system the bulk cargo is bagged at or near the receiving port using either portable or permanent bagging facilities. Such a local bagging system can result in savings of US $20/tonne or more. The savings, of course, can vary significantly depending upon the supply source, type of local bagging facility, cost of empty bags, and cost of local labor.

The most essential element in operating an efficient local bagging system is skilled management and supervision coupled with the full cooperation of the port authority, local transport authorities, and local labor organizations. If these elements are not effectively in place, local bagging can lead to excessively high costs due to ship demurrage, waste of fertilizer, costly storage, and untimely delivery to the farmer. Many of these problems were encountered in Ghana when local bagging was implemented at the Tema Port in the mid-1970s (Russell et al., 1973).

The following example (**Table 6**) illustrates the possible saving in cost that can be achieved through a well-managed local fertilizer bagging operation. It is important to note that most of these savings represent foreign exchange, which is most often in short supply.

Savings Through Local Processing of Imported Materials--After skill in bulk importation and local bagging has been demonstrated and the favorable economics are verified, local blending of imported bulk materials to produce multinutrient (NPK) fertilizer mixtures (blends) is often suggested as the next logical step of development in the fertilizer supply system.

If properly processed, locally blended fertilizers can replace imported homogeneous granular NPK compounds, which are often more expensive. Of course, blending has its limitations and therefore should not be universally recommended as a viable alternative to imported compounds. The most serious limitation encountered with blending is the lack of high-quality granular raw materials at cost-effective prices. Also, uniformly incorporating small quantities of required secondary and micronutrients such as magnesium, sulfur, boron, and zinc when blending can often be a problem that is technologically difficult and costly to solve. The chemical quality of blended fertilizers, and therefore their agronomic effectiveness, is almost entirely dependent upon the quality of the raw materials. Therefore, the highest priority must be given to the procurement and use of premium quality granular raw materials to ensure that the farmer receives the product that he pays for.

As illustrated (**Table 7**), savings of about $30-$60/tonne can be realized over imported bagged NPK compounds by importing the raw materials in bulk and blending and bagging them locally. Of course, the level of savings will vary significantly depending upon the grade of fertilizer and the international pricing structure.

It is important to remember that, although blending offers considerable flexibility with regard to the number of grades that can be produced, the agronomic recommendations should be simplified and based on the use of materials that are widely available on the international market. Also, it is extremely important to minimize the number of recommended grades and thereby keep raw material and product storage costs at a minimum.

Table 6. Potential Savings Due to Bulk Import and Local Bagging of Fertilizer

Cost Saving Component	Potential Saving Over Bagged Fertilizer Imports (US $/tonne)
1. Avoid high cost of bagging and stevedoring in the developed countries as compared to local costs	15-25
2. Lower ocean freight for bulk material compared with bagged material	2-5
Potential Saving (compared with importation of bagged fertilizer)	17-30

Local Manufacture of Granular Compound Fertilizers--The local production of granular compound fertilizers is often proposed for many of the less-developed countries. Unfortunately, this fertilizer supply alternative often meets with failure and therefore is not generally advised. The following area some of the major reasons for the lack of success:

1. The fixed capital investment for the granulation plant and the required raw material storage facilities is quite high-typically in the range of US $10-$20 million depending upon the process and a number of site-specific factors (**Figure 5**).

2. The local demand for fertilizer is generally small and uncertain; plant capacity utilization is therefore low and costs are excessive mainly because the fixed cost of production (especially capital recovery charges) is relatively high.

3. A large amount of raw materials must be imported to supplement locally available materials. This leads to constantly recurring costs (allocation of foreign exchange) for purchases on the international market.

4. Large raw material inventories must be maintained to achieve the cost benefit of large cargos and to maintain raw material security, which means an unusually high demand for working capital.

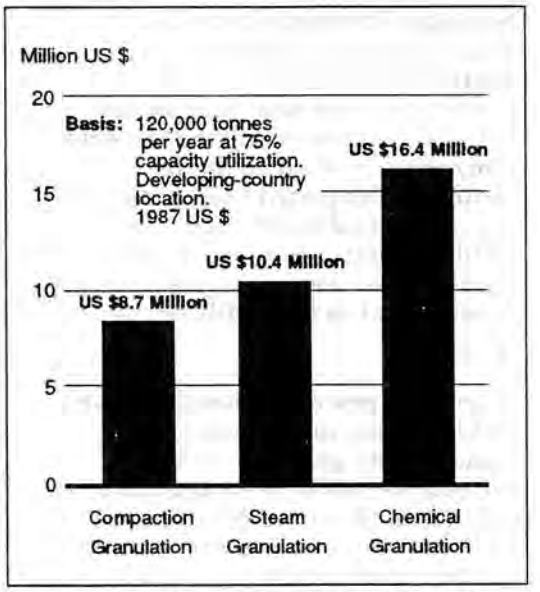

Figure 5. Approximate Fixed Capital Investment for Various NPK Granulation Processes.

Table 7. Potential Savings Due to Local Blending of NPK Fertilizers to Replace Imported Compounds

Fertilizer Grade	Imported Bagged Compound (Typical 1987/88)	Imported Bulk Materials With Local Blending and Bagging (US $/tonne)	Savings
15-15-15	215	159	56
20-10-10	245	208	37
15-15-15-6S-0.3B	256	226	30
20-10-15-5S-0.3B	279	222	57

5. The cost of nongranular raw materials available on the international market is often not significantly less than the cost of granular materials. An example of the typical cost of nongranular raw materials used to produce a granular 15-15-15 fertilizer compared with granular materials used for blending a 15-15-15 is shown in Table 8. These data indicate an approximate US $12/ tonne saving in raw materials for granulation. However, this saving is offset by the high cost of production for granulation, which makes blending more attractive from an economic point of view, as shown in **Figure 6** and **Table 9.**

In this example (**Table 9**) typical fixed capital investment requirements and expected factory-gate production cost for a granular 15-15-15 fertilizer produced in three different types of granulation plants are compared with costs of blending.

For comparison, the average 1988 f.o.b. Western Europe price for bagged 15-15-15 was US $155/tonne (Green Markets, 1989). This would translate to a delivered cost of about US $215/tonne (assuming US $60/ tonne for ocean freight and port handling). It is important to note that the factory-gate production costs shown in Table 9 assume a plant capacity utilization of 75%, which is equivalent to 120,000 tpy. If

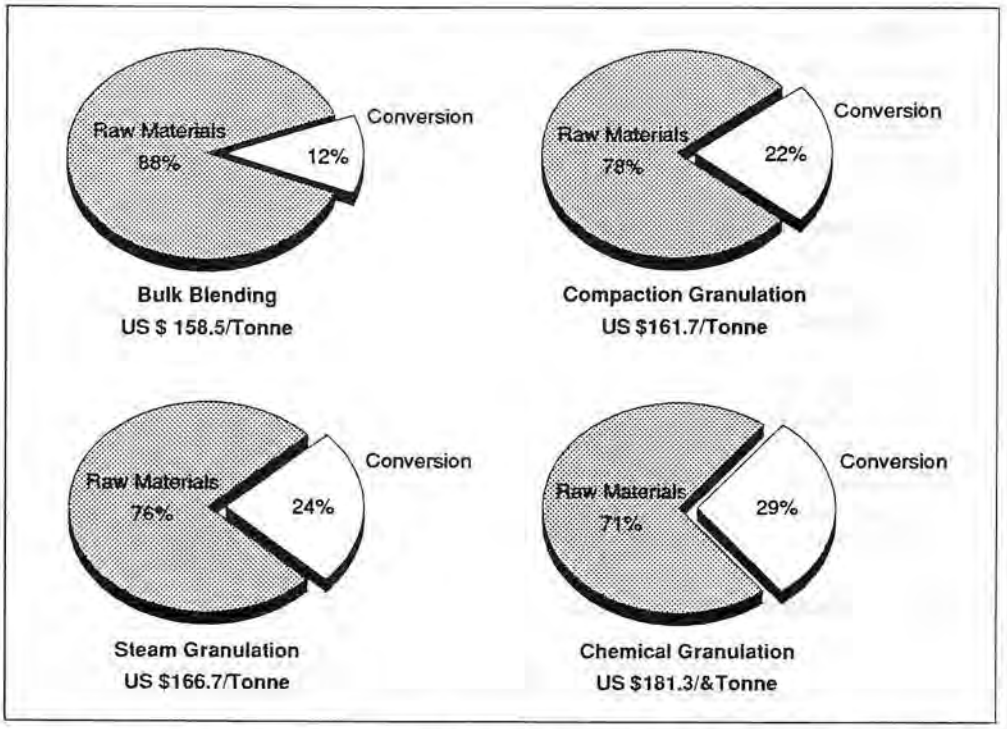

Figure 6. Approximate Distribution of Production Cost for Various NPK Production Processes--15-15-15 Product.

Table 8. Estimated Raw Material Cost for Various NPK Production Processes (15-15-15 Product) in Developing Country Location

Raw Material[a]	NPK Production Process			
	Bulk Blending	Compaction Granulation	Steam Granulation	Chemical Granulation
	(US $/tonne 15-15-15)			
Prilled urea-46-0-0 (US$125/tonne)	-	16.6	16.6	13.1
Granular urea-46-0-0 (US$130/tonne)	5.2	-	-	-
Nongranular monoammonium phosphate-10-50-0 (US$200/tonne)	-	60.8	60.8	-
Granular diammonium phosphate-18-46-0 (US $215/tonne)	71.2	-	-	-
Standard ammonium sulfate-21-0-0 (US $80/tonne)	-	23.0	23.0	-
Granular ammonium sulfate-21-0-0 (US $95/tonne)	33.7	-	-	-
Standard muriate of potash-0-0-60 (US $95/tonne)	-	24.3	24.3	24.3
Granular muriate of potash-0-0-60 US $105/tonne)	26.7	-	-	-
Ammonia-82-0-0 (US $135/tonne)	-	-	-	17.1
Sulfuric acid-96% H2SO4 (US $80/tonne)	-	-	-	20.8
Phosphoric acid-52% P_2O_5 (US $170/tonne)	-	-	-	51.5
Conditioning clay (US $40/tonne)	0.6	0.6	0.6	0.6
Conditioning binder (US $300/tonne)	1.5	1.5	1.5	1.5
Total (Raw Material Cost)	138.9	126.8	126.8	128.9

[a] Indicated raw material prices based on 3,000-5,000 tonne lots delivered to plant site (mid-1987 international f.o.b. prices plus US $30/tonne for solid materials and US $40/tonne for liquid materials).

the actual plant capacity should decline below this value, the cost of production would increase significantly, as shown in **Figure 7.** In general, it is unlikely that a granulation plant of this capacity (about 120,000 tpy) can be routinely cost effective compared with the importation of granular compounds. Because of these factors the decision to invest in such local granulation facilities should be approached with a great deal of caution.

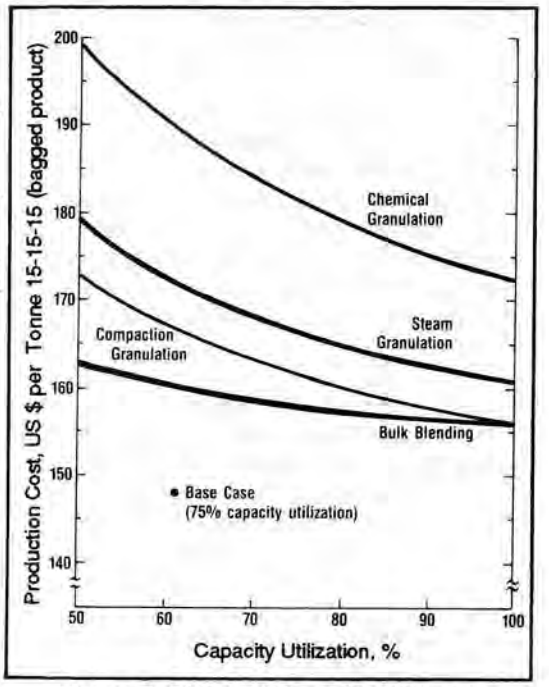

Figure 7. Effect of Capacity Utilization on Factory-Gate Production Cost for 15-15-15 Produced by Various NPK Production Processes--New Facility. Source: Schultz and Parish, 1989.

Other Local Production Methods--As previously indicated, many African countries have phosphate deposits. These deposits are quite variable in quality (McClellan and Notholt, 1986). However, some countries, for example, Mali and Tanzania, have deposits of phosphates that are naturally quite reactive and therefore agronomically available. Simple processing of these materials (screening, washing, and grinding) to make them suitable for direct application to the soil should be encouraged. Such processing is not capital intensive and does not require the recurring importation of additional raw and intermediate materials required for the more sophisticated and capital-intensive chemical processing routes.

Table 9. Estimated Fixed Capital Investment and Production Cost for NPK Granulation (NPK 15-15-15 Used for Example)

Type of NPK Granulation Plant	Fixed Capital Investment (million US $)	Factory-Gate Production Cost		
		Raw Materials[a]	Conversion[b]	Total
		(US $/tonne 15-15-15)		
Compaction/granulation	8.7	127	35	162
Steam granulation	10.4	127	40	167
Chemical granulation	16.4	129	52	181
Bulk blending (shown for comparison)	3.2	139	20	159

[a] Raw material cost based on values shown in Table 8.

The Importance of Stepwise Development

When formulating a fertilizer supply strategy it is most important to minimize the fixed cost of the system. Therefore, it is essential that the complexity of the system, and therefore the amount of required fixed capital investment, be closely tailored to the actual demand for fertilizer.

Because the current demand for fertilizer in Ghana and most other sub-Saharan countries is small but expected to grow gradually, the initial basic fertilizer supply system should be simple but designed for growth. As demand for fertilizer grows, the system should be developed in a stepwise fashion to meet the demand.

An example of a fertilizer supply and investment strategy that would be very appropriate for Ghana and many other countries with a modest but growing demand of fertilizer is shown in **Figure 8**. The steps of this development plan are summarized:

Step 1: Importation of bagged products--This option is usually the most cost effective until the annual demand reaches about 25,000 tonnes. For a cost-effective supply system, all that is needed is a well-managed and efficient demand forecast and procurement unit together with the timely allocation of foreign exchange.

Step 2: Importation of bulk products with local bagging--This alternative usually becomes cost effective when annual demand is in the range of about 25,000-75,000 tonnes. All the elements of Step 1 are required. If properly executed, Step 2 will accrue additional savings due to the use of local resources for bagging and more favorable bulk shipping rates.

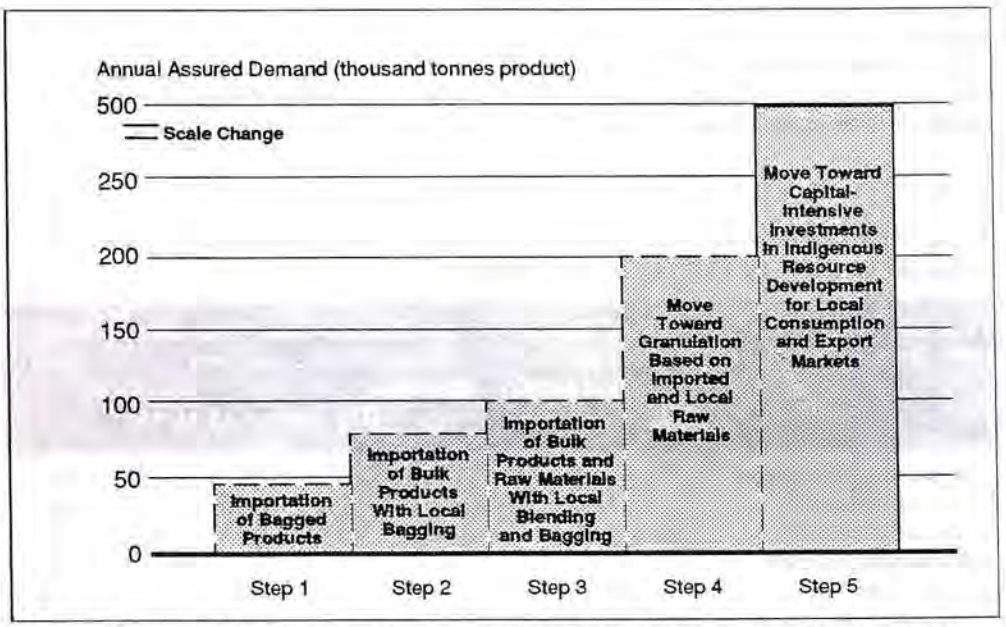

Figure 8. Example of Stepwise Development of Fertilizer Production/Supply Units.
Source: Schultz and Parish, 1989.

Step 3: Importation of bulk products and raw materials with local blending and bagging--The transition to Step 3 should be delayed until it is certain that blending is actually needed. Also, because of the larger investment required, the annual demand should be in the range of 75,000-100,000 tonnes.

Step 4: Local production of granular products based on imported and domestic raw materials--Because this option is quite capital intensive, the annual demand must usually exceed about 150,000 tonnes for such a supply system (granulation plant) to be cost effective. Implementation of this step in development should be approached with a great deal of caution.

Step 5: A world-scale domestic production unit designed to exploit a domestic fertilizer resource such as natural gas or phosphate or should be considered only if there is an assured market (at favorable prices) to absorb the excess production and thus ensure that the factory will operate at a high capacity utilization.

Of course, the point at which one supply method gives way to another depends on a number of site-specific factors. However, for any fertilizer supply system to be cost effective, its fixed cost of production (supply) must remain low and the system must meet the farmers' needs in a timely manner that is profitable to him.

Importance of Using High Analysis Fertilizers

There is an urgent need to shift from low- to high-analysis fertilizers in Ghana and also in most other African countries. In 1986 Ghana imported 8,500 tonnes of sulfate of ammonia (SA) containing 21% N and 24% sulfur, and no urea (46% N) was imported. Because the nitrogen content of urea is almost double that in SA, nitrogen in the form of urea will be considerably less expensive to purchase, ship, store and handle, and apply. To illustrate the potential saving that is possible by shifting to high-analysis fertilizers, a comparison of SA and urea is made. At current prices, the delivered cost (f.o.b. Western Europe plus freight) per kilogram of N is $0.57 for SA compared with $0.33 for urea. The potential savings for purchasing and using urea instead of SA amounts to $0.24/kg of N. For example, the amount of N in an 8,500 tonne shipment of SA would cost approximately $428,000 more than the same amount of N contained in only about 3,900 tonnes of urea. There are also additional savings on internal freight, warehousing, bagging, and handling. The same magnitude of savings is possible with respect to high-analysis phosphate and NPK fertilizers. It is important that Ghana take advantage of the potential savings that can be realized by shifting to high-analysis fertilizers where practical.

An Effective Fertilizer Marketing System

The recent Ghana Fertilizer Privatization Study (IFDC, 1986) indicates that the fertilizer marketing system "is inefficient and costly to the Government." This is true for most fertilizer marketing systems in Africa. Large benefits can be realized simply by performing the marketing functions in a more efficient manner. The Purpose of a good fertilizer marketing system is to make the appropriate fertilizers timely available to farmers within a

reasonable distance and in the most cost-effective manner. Fertilizer marketing is often misunderstood. To some it means selling. To others it may mean physical distribution, promotion, wholesaling, or retailing. Actually it is all of these and more.

"Fertilizer marketing embraces all business activities involved in the flow of goods and services from production to consumer, including the elements of forecasting, the need for and deciding the *product*, providing place *utility*, product *pricing*, and *promotion*."

These activities are viewed from the position of satisfying the end user's (farmer's) demand for fertilizers, and the performance of these functions in an order constitutes the marketing system.

A total marketing system is a combined effort of all organizations and their people that perform the marketing functions. The functions may be performed by as many as seven, eight, or more or by a single organization. If there is more than one organization performing the marketing functions and they are not coordinated under one organization, it would be classified as *unintegrated*. If a single organization performs all the functions, it would be centrally managed and classified as *integrated*.

Figure 9 is an organizational chart for an integrated fertilizer marketing system. The functions are product, place, pricing, and promotion and are carried out under a functional single management straight line organization. Principal characteristics of an integrated marketing system are:

a. One autonomous organization having authority, responsibility, and accountability for all marketing activities.
b. Authority, responsibility, and accountability are vested in the lowest levelemployee responsible for the activity.
c. Marketing objectives are specified.
d. Detailed job descriptions with scheduled objectives are implemented.
e. The right to hire, dismiss, and promote personnel based on job performance.
f. Cost-effective budget programs.
g. The system is self-supporting through profits generated.
h. The retail-dealer satisfies his customer's needs on an on-going basis.
i. Have intensive programs of employee training and development.

An unintegrated fertilizer marketing system similar to that used in many public sector operations is shown in **Figure 10**. The marketing functions can be the same as those carried out in the integrated system; however, the degree of efficiency in carrying out the functions is not equal. In an integrated system fertilizer is their only business. In an unintegrated system fertilizers are often a secondary activity. In an unintegrated system communications between organizations can be less than adequate. Simply stated, in an unintegrated fertilizer marketing system the organizations are responsible for several activities and do not spend the required time to carry out the fertilizer marketing fundtions adequately.

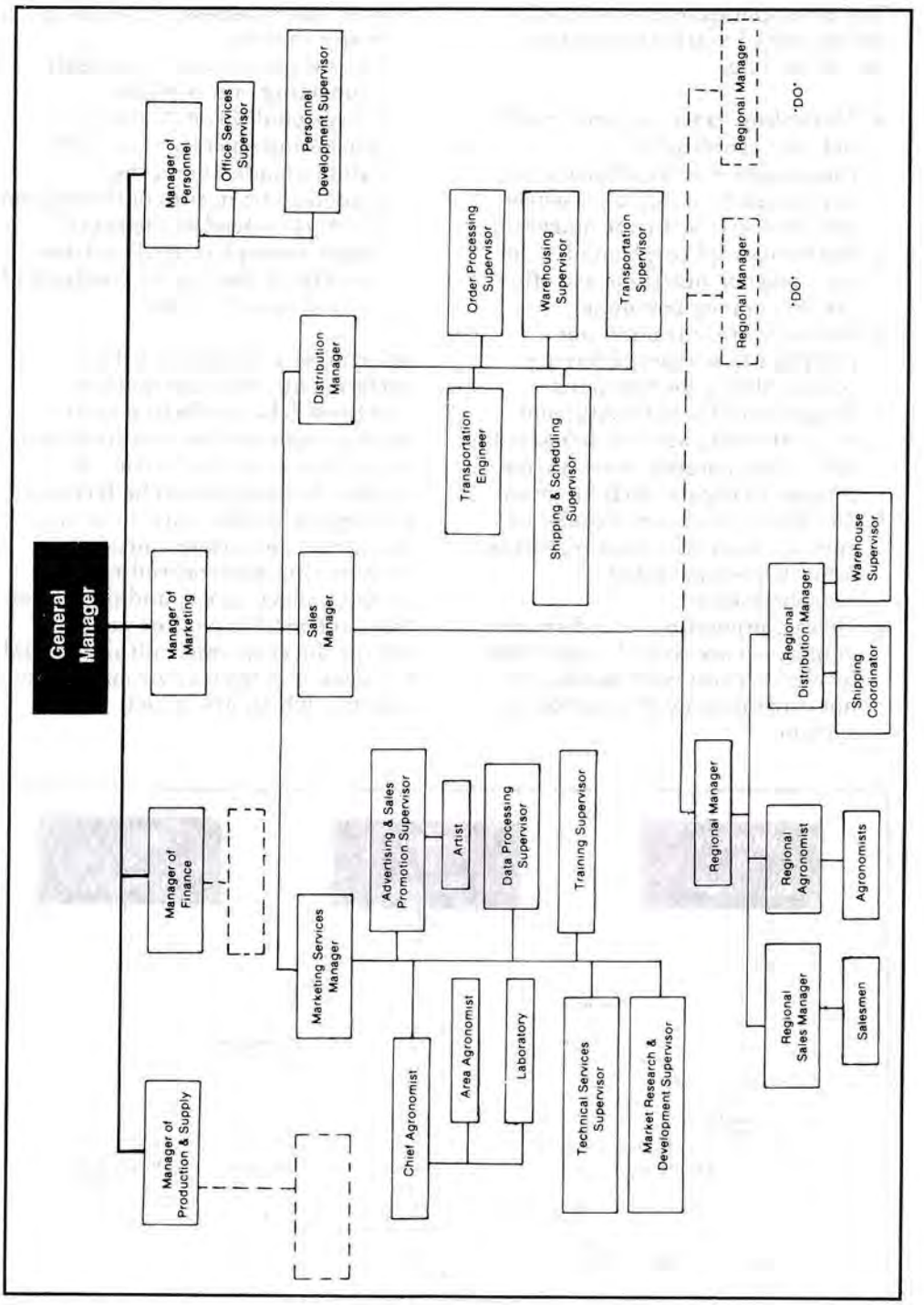

Figure 9. Organizational Chart of an Integrated Fertilizer Marketing System.

The principal characteristics of an unintegrated marketing system would include:

a. Marketing functions are usually not well coordinated.
b. Coordination of functions is not performed by a manager whose sole interest ifertilizer marketing.
c. Authority and responsibility for carrying out functions are often divided among personnel.
d. Accountability is often not assigned to personnel having responsibility for functions.
e. Responsibility, authority, and accountability are not delegated to the lowest possible level having responsibility for each function.
f. Job descriptions are usually not specific and often employees have other time-consuming responsibilities.
g. Hiring, promoting, and dismissing employees are usually controlled by civil service regulations and not controlled by the marketing system.
h. Cost effectiveness is usually not a major concern.
i. The system is usually not self-supporting and is made operational through subsidies.
j. Marketing objectives are not usually made due to the monopolistic nature of the system.
k. Stockist instead of the retail dealer concept is used and does not offer a continuous feedback of market requirements.

A fertilizer marketing system performs all of the marketing functions. The marketing system must provide for the coordination of the resources and activities for market development. The fertilizer marketing system must focus on satisfying the farmer's needs by determining and controlling the product, place, price, and promotion often referred to as the four P's within the economic, cultural, social, political, and legal environments of a country, which are called

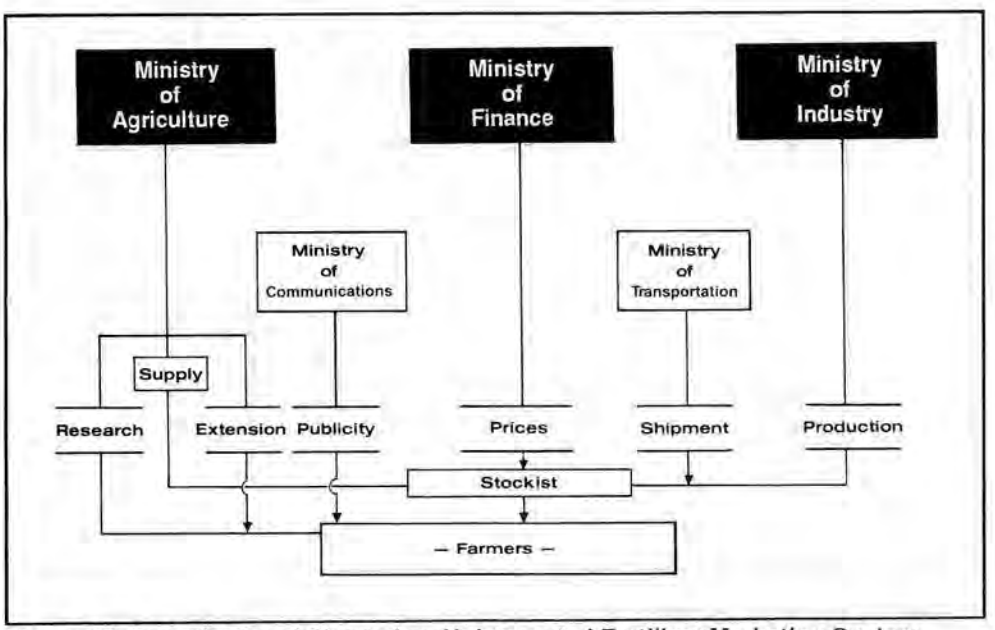

Figure 10. Organizational Chart of an Unintegrated Fertilizer Marketing System.

uncontrollable factors. **Figure 11** illustrates the normal controllable and uncontrollable factors.

In the past few years governments of several countries have taken over fertilizer marketing systems that were using the integrated organizational structure. Immediately after takeover, the integrated system was abandoned and an unintegrated system substituted. Marketing costs seem to always increase due to bureaucratic inefficiencies. This leads to higher fertilizer cost to the farmer or to the government in the form of a subsidy. Sooner or later governments arrive at the conclusion that it cannot directly operate an efficient fertilizer marketing system.

A principal reason that governments take over fertilizer marketing systems is to gain control of the fertilizer industry. Governments seem to think that control of the fertilizer business will guarantee cheap fertilizer prices and low food cost in the cities. It does not happen that way. When governments take over and try to run a fertilizer business the cost usually go up. An efficient fertilizer marketing system is essential to keep costs down. There is a way for governments to *have control* and not be directly involved in carrying out the marketing functions. **Figure 12** charts a method of government ownership that incorporates key features of the integrated fertilizer marketing system. This hybrid closely resembles the organization of wholly owned government companies (parastatals) that exist in some countries. The board of directors is appointed by the highest government office (head of state, prime minister, president, etc.) from among the principal ministries. The board of directors selects and appoints the chief operational officer (president, general manager, or managing director). The board of directors establishes policy and keeps their hands out of the operations. The general manager is responsible for implementing the policy. The general manager is responsible to the board of directors. All marketing personnel are responsible to the general manager.

The efficiency of performing marketing functions is a condition of organizational structre and management and not a method of ownership. Governments can have the

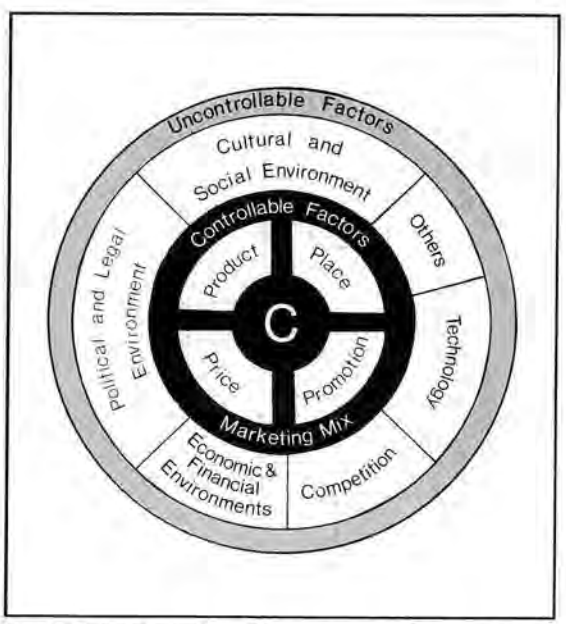

Figure 11. Marketing Management Focuses on Satisfying the Farmer Using the Controllable Factors Within an Uncontrollable Environment.

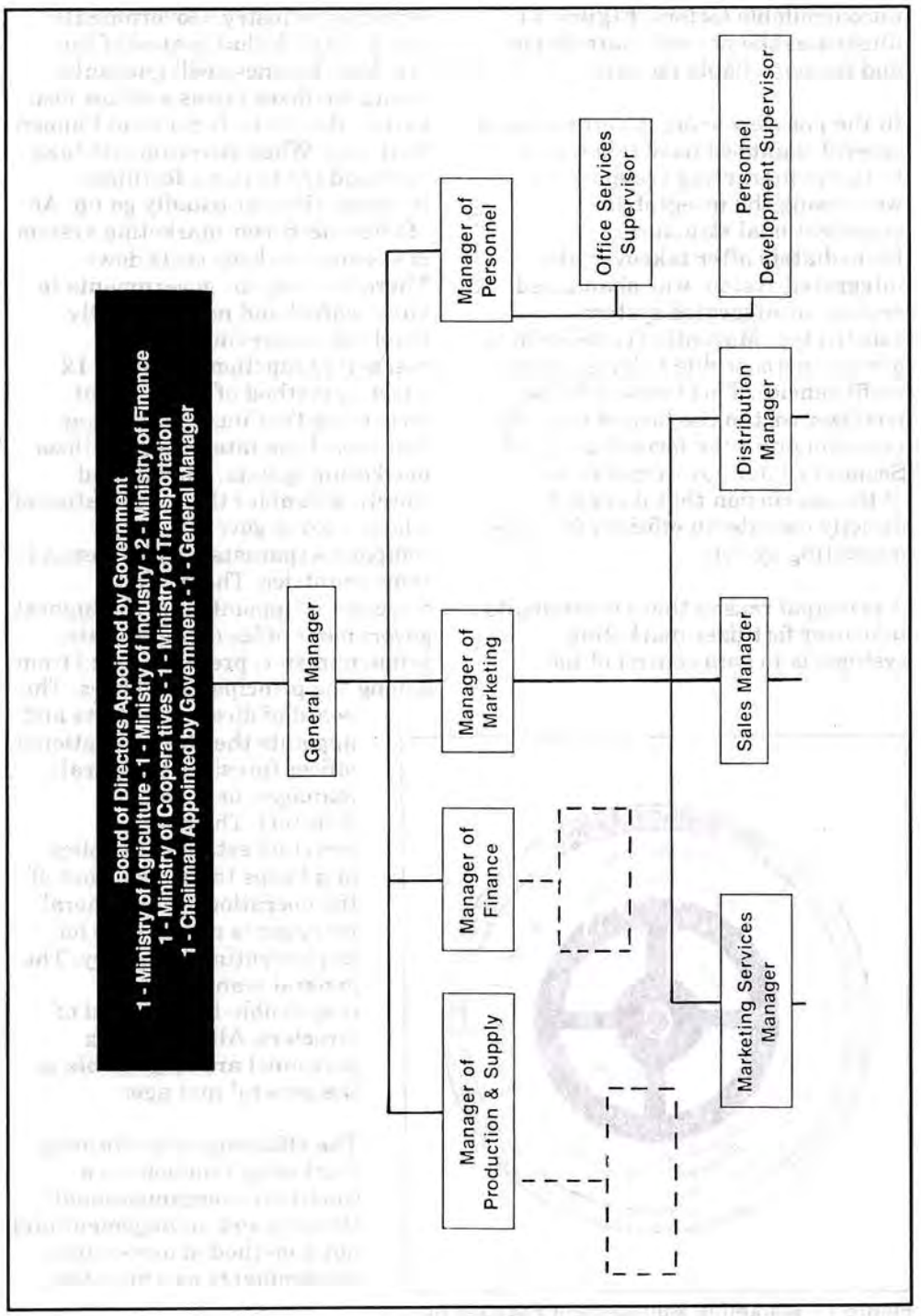

Figure 12. Organizational Chart of a Government-Owned and Controlled, Integrated Fertilizer Marketing System.

best of both worlds--efficiency of operation with an integrated system and control with the development of an autonomous organization under the guidance of an appointed board made up of government officials.

An effective fertilizer marketing system can also make other essential crop production inputs available to farmers. The marketing system can deliver all tangible inputs, (i.e., insecticides, herbicides, seed, equipment). It can also deliver intangibles like technology and information on how to use the product and grow better crops. Some of the other activities that are necessary for an effective fertilizer marketing system include:

An Effective Extension Service

An effective extension service to complement the fertilizer marketing system is essential. There are still many farmers in Ghana that are not aware of the benefits of fertilizer. A mass educational program to teach farmers the proper use of fertilizers and benefits is essential to an effective fertilizer sector. In many countries the extension service is in name only. Officers do not have funds for travel or means for carrying out educational programs. Women should be included in fertilizer educational programs because they do much of the crop production work and marketing of the crop produce. There are several proven educational tools that extension service should continue to utilize. These include: demonstrations-a comparison of a correct practice with the farmer's normal practice (Global 2000), crop production meetings-called meetings in convenient places to discuss correct practices, and educational materials-leadlets, brochures, posters, etc., in the local languages and in an easy-to-understand form.

An Effective Crop Produce Marketing System

Farmers are not too different from most businessmen. They are in business to make money to support a given life-style for themselves and their families. Farmers often produce a good crop and then learn that the market has disappeared and at best they can only sell at a reduced price. A fertilizer marketing system can also provide the farmers a place to sell their crop produce. Retailers can be buying agents on behalf of the government or as private organizations. Farmers only want a chance to make a profit. Given that opportunity they will produce. What does it take as for crop marketing for farmers to take the risk and produce crops. They need: a structured market-one that is always dependable, markets reasonably close, competitive markets that provide "fair" prices, prices that provide a favorable value: cost ratio, storage facilities for different crops, and added value in the form of processing, grading, packaging, and cleaning.

Personnel Development Programs

An organization is only as good as the people employed and trained to carry out its many functions. One of the main problems in many countries in Africa is that employees are not selected on capability, trained to develop their highest capacity, and then left on the job long term to perform and train

others. Instead of the best possible person being selected, positions are sometimes awarded to relatives and friends.

In some countries the potential supply of qualified staff to run an effective fertilizer sector is limited. Curricula in colleges need to be reevaluated in realtion to the positions and functions required in the fertilizer sector. For example, most agricultural colleges do not offer courses in fertilizer marketing. Because of this deficiency the fertilizer sector must focus on a strong training program for specific jobs and functions. This can be accomplished through formal degree courses in universities and colleges (i.e., chemistry, geology, marketing, transportation, etc.) or through on-the-job nondegree training for specific positions.

Infrastructure to Support a Fertilizer Sector

Providing the required support for a successful fertilizer marketing system is a never-ending task. As the fertilizer sector matures, the amount of infrastructure required also increases. New technologies, demand for more and better service, volumes to be handled, and cost of doing business are reasons why the support systems are constantly required to change. Some of the key infrastructure required include:

a. Farm-to-market roads--Farmers must be able to get inputs and output in and out. Farm land needs to be opened up to development.
b. Trunk roads--Major cities and agricultural-producing areas should be linked.
c. Railroads--An inexpensive form of transportation is not being fully utilized. There should be new roads, new equipment, and new facilities brought into service.
d. Waterways--In many countries water routes are not being developed. It is one of the cheapest forms of transportation and should be developed where practical.
e. Storage and handling facilities--A huge quantity of crop produce spoils annually in sub-Saharan Africa because of inadequate storage and handling facilities. Storage facilities should start on farms and village submarkets with larger facilities on main transport lines and consumer markets. Storage and handling facilities should iclude cold storage for food crops as well as silos for cereals.
f. Facilities for added value Includes crop processing facilities (i.e., juice from fruit, tomato paste from tomatoes, and grading and packaging for consumer markets. Added value to crop produce can increase employment, save foreign exchange, and enhance bartering while supplying markets for the farmers.

An Effective Agricultural Credit Program

This translates into purchasing power for the manufacturers, marketers, and farmers. An effective credit program does not mean a give-away program or one in which borrowers do not expect to repay loans. It does mean ones where reliable businessmen meeting loan criteria can obtain production loans at favorable interest rates. There are different types of loans: inputs in kind, retailer credit, manufacturers credit, processor credit, and farm crop production loans.

Government Policy to Support an Effective Fertilizer Sector

It is impossible for any component of a fertilizer sector to be successful without the support of government. A government cannot guarantee success; however, it can create a favorable environment that eliminates constraints from government involvement. Government policy should aid development of a successful fertilizer sector instead of handicapping its development. Some areas where positive government policy are needed include:

A clear definition on the role of government and private industry in development and operation of a fertilizer sector. Short-term and long.term roles and how these roles change as sector matures should be cited. The definition should include government's role in:

(a) Regulatory and quality control functions and enforcement.
(b) Monitoring and evaluation of sector performance.
(c) Agriculturalresearch and development.
(d) Conditions or circumstances under which intervention will be justified such as poor performance, inadequate competition, shortages of food, and force majeure.
(e) Provision of incentive programs on capital formation and development of facilities, tax holidays, tariffs, staff promotion, etc.

Establish policy that will define the role of women in agriculture and allow women to participate in all aspects of crop production and marketing.

Establish policy that will allow fertilizer industry concerns to function as autonomous self-supporting organizations.

A National Fertilizer Sector Plan

A detailed national plan is necessary for the development of a successful fertilizer sector. Most countries do not have a specific plan. They do not know what they want as for supplies, manufacturing, and marketing in 10-15 years. A 5-year country plan is usually not in adequate detail and timeframe to provide guidance for developing a fertilizer sector. The plan should be an action schedule of events designed to produce desired results. Once a fertilizer sector plan has been developed, sufficient time should be allowed for execution before major changes are made. The direction of development should not change with every new administration.

A national fertilizer sector plan should identify and determine what is needed and wanted in the long term on fertilizer supply, manufacturing, and marketing; identify national agricultural goals and the role of the fertilizer sector in helping to accomplish these goals; identify and detail the fertilizer marketing system that best meets the needs of the country; identify participants' functions by time periods; establish provisions for the allocation of resources to carry out the plan; make plans available to all participants; include monitoring and evaluation procedures; and establish provisions for taking corrective measures.

Savings Through Improved Physical Distribution

In many African countries one of the first steps in improving fertilizer marketing is to improve physical distribution. Even if an improved marketing organization cannot be installed improvements in physical distribution can be made profitably. Huge sums of money are being lost through inefficient distribution systems. In some countries the loss in material alone amounted to 10% of the product cost.

As **Table 10** shows, an efficient distribution program involving 30,000 tonnes of product can provide benefits of US $1.1 million or about US $38/tonne of fertilizer.

The following areas are among those offering the highest potential of savings in Ghana.

1. **Transportation**--The most cost-effective transportation modes are often not used. Road transportation seems to receive a priority even when rail and water transportation is available; this may be due to the need to rush the fertilizer supply to the farmers, inadequate rail, and water transport equipment, and inadequate planning. Rail costs in Ghana are from 50% to 75% those of truck transport (IFDC, 1986). When fertilizer shipments are interrupted by warehousing, the transportation cost goes up by 25%-30%. A significant saving can be realized by using rail transportation and eliminating intermediate warehousing.

2. **Warehousing**--To warehouse fertilizers accrues costs in three ways:

   a. The extra transportation cost as mentioned above.
   b. The operating cost of the warehouse.
   c. The material loss that inevitably occurs when handling fertilizer.

   It seems that far too many fertilizer distribution programs center on warehousing. In Ghana, for example, it is estimated that national storage capacity is about 98,000 tonnes of product or about 3.2 times 1987 sales of 30,200 tonnes (IFDC, 1986). There are over 400 sales points in Ghana with underused storage facilities. Fertilizers should be put through as few warehouses as possible en route to the farmer, as illustrated in Figure 9. Besides the extra transportation costs for breaking the journey to the farmer, there is a 1%-2% product loss under African conditions for each warehousing operation. On a $300/tonne product cost this loss could amount to $6/tonne. If one warehousing operation can be

Table 10. Potential Benefits of an Efficient Fertilizer Distribution System Handling 30,000 Tonnes of Product

Operation	Potential Saving (US $)
1. Transportation--Eliminating 1 journey break saving $7/tonne in freight and handling	210,000
2. Warehousing--Reduced product loss (US $6/tonne)	180,000
3. Decrease working capital by decreasing inventory carryover (US $25/tonne)	750,000
Total	1,140,000
Saving Per Tonne of Fertilizer	38

eliminated, as much as US $4/ tonne can be saved.

3. **Working Capital**--When fertilizers are not used in a cropping season, they are usually carried over to the next season. How long the fertilizers will remain in storage depends on rainfall patterns (one or two planting seasons), the types of fertilizers in storage, and the crops to be fertilized. It costs money to carry fertilizers in inventory. An efficient marketing system will normally order the correct quantity of fertilizer and have it in place to minimize the carry-over cost. A $300/tonne product at a 10% annual interest rate carried over for an extra 10 months will cost the marketing system $25/tonne.

Another benefit of an efficient fertilizer marketing system for Ghana is higher crops yields. When fertilizers reach the farmers late, the ideal time for application and maximum yields can be missed. The reduced yields translate into a financial loss for the individual farmer and losses to the national economy. Many times foreign exchange will be needed to import food to offset the loss in domestic production. Depending upon the crop grown, the loss in yield can be substantial. On maize, for example, a yield loss of up to 5 tonnes/ha or more is possible when fertilizers are not applied on time. Assuming that 30,000 tonnes of fertilizer was purchased but not applied, the maize yield loss could amount to some 150,000 tonnes of grain. At current maize prices it would cost the national economy approximately $22.5 million to replace this grain loss. Therefore, after the fertilizer cost is deducted, a net economic gain of about $15 million would be possible as a result of timely application of fertilizer.

The importance of Foreign Exchange

The countries of sub-Saharan Africa have essentially agricultural-based economies and rely heavily on imported industrial products. The availability of foreign exchange is therefore a vital component in their development planning. The debt service (the amount of export earnings, expressed as percentage, needed to service the country's outstanding debt) of many African countries is very high and thus severely restricts available foreign exchange that can be allocated for fertilizer imports or for investments in domestic production facilities. Unless the debt service burden is decreased to a manageable proportion, there is little hope for bringing about the economic conditions needed for steady growth of an intensive agriculture sector, the main prerequisite for the economic operation of fertilizer production/supply units. The typical debt service burden for selected African countries is shown in **Table 11.** Fortunately, Ghana is among the most favorable of the African countries with respect to debt service.

Unfortunately, the foreign exchange component of most fertilizer supply systems is quite high-typically in excess of 50%. Even in production units based on the exploitation of domestic fertilizer resources, for example, natural gas or phosphate rock, the foreign exchange component of the total production cost is very significant. As previously shown in Table 3, the

foreign currency cost of urea, based on locally available natural gas, is equivalent to about US $135/tonne of urea or almost 60% of the total factory-gate cost of production. Likewise DAP (Table 4), based on locally available phosphate rock and imported sulfur and ammonia, has a foreign currency cost of about US $210/tonne or about 65% of the total production cost.

The stepwise development of the fertilizer supply system for Ghana as described in this paper will result in significant savings of foreign exchange. For example, of the potential savings that could accrue through (1) improvements in the overall management and operation of the procurement system, (2) importation of bulk fertilizer with local bagging, and/or (3) local blending to replace more expensive imported compounds, about 50% would be in the form of foreign currency. Such savings in foreign exchange would have a very positive impact on the economy of Ghana.

Table 11. Debt Service for Selected Countries, 1986[a]

Country	Outstanding Long-Term External Debt (million US $)	Debt Service, 1986 (%)
Burkina Faso	616	14.8
Cameroon	2,772	22.8
Ghana	1,413	10.8
Madagascar	2,635	27.7
Malawi	910	40.1
Niger	1,251	40.3
Nigeria	21,876	23.4
Senegal	2,471	20.2
Somalia	1,415	62.1
Togo	882	32.5

[a] Debt repayment (principal plus interest) expressed as a percentage of income earned from export of goods and services in year specified.

Source: World Bank, 1988.

Conclusion

Many opportunities exist whereby Ghana and other countries in sub-Saharan Africa can decrease the farm-level cost of fertilizer. A summary of options together with the estimated attendant saving over the current ad-hoc or "standard" practice follows

Fertilizer Supply Activity	Potential Savings Over Current Practice (US $/tonne fertilizer)
Improvements in demand forecasting, procurement, and logistics	60-160
Importation of bulk fertilizer products with local bagging	17-30
Importation of bulk fertilizer products and raw materials with local blending and bagging	30-60
Local granulation of NPK fertilizers based on imported and domestic raw materials	Only marginal savings over bulk unless annual tonnage exceeds about 150,000
Improvements in	30-40

The effective implementation of activities 1, 2, and 5 would have the potential of decreasing the farm-level cost of fertilizer in excess of US $100/tonne when compared with current practice. Such savings would

mean that the unsubsidized cost of fertilizer to the farmer would be well below its current cost.

Thus it becomes clear that every effort should be made to increase the priority given to the skilled and effective management of the fertilizer supply system in Ghana and elsewhere and to provide those modest investments needed to bring about a sound, well-managed, and cost-effective supply of fertilizer to the African farmer.

Fertilizer marketing is often misunderstood. It embraces all business activities involved in deciding what products are needed, the physical distribution, pricing of the products, and promotion to encourage the farmers to use the products correctly.

Fertilizer marketing systems in Africa are many times structured on whelms rather than efficiency of operation. Integrated fertilizer marketing systems are centrally managed and are more efficient than unintegrated systems. Governments can own integrated marketing systems and enjoy the efficiency of operation and the lower cost of fertilizer than can be provided through an unintegrated system.

Activities required to support an effective fertilizer marketing system include an effective extension service, a good crop produce marketing system, personnel development programs, transportation and storage facilities, agricultural credit, positive government policy, and a national fertilizer supply and marketing plan. Without a plan the fertilizer sector will continue to drift without purpose.

References

FAO. 1988. FAO Fertilizer Yearbook 1987, Vol. 37, FAO, Rome, Italy.

Green Markets. Volume 13, Number 28, July 17, 1989, New York, New York. McGraw-Hill.

IFDC. 1986. Ghana Fertilizer Privatization Study. Report submitted to the Ministry of Agriculture, Accra, July 1986.

McClellan, G.H., and A.J.G. Notholt. 1986. "Phosphate Deposits of Tropical Sub-Saharan Africa." In Management of Nitrogen and Phosphorus Fertilizers in Sub-Saharan Africa, pp. 173-223, Martinus Nijhoff Publishers, the Netherlands.

Nye, P.H., and D.J. Greenland. 1960. *The Soil Under Shifting Cultivation*, Technical Communication No. 51. Commonwealth Bureau of Soils, Commonwealth Agricultural Bureau, Farnham Royal, Bucks, England.

Potash and Phosphate Insitute, 1988. "Potassium For Agriculture International," *Better Crops International*, Vol. 4, No. 2, December 1988.

Russell, D.A., Grisso, R.D., and Lee, R.G. 1973. *Fertilizer Alternatives for Ghana*, Bulletin Y56. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama.

Schultz, J.J., and D.H. Parish. 1989. *Fertilizer Production and Supply Constraints and Options in Sub-Saharan Africa*, P-10, International Fertilizer Development Center, Muscle Shoals, Alabama.

Wiersholm, L. 1989. "Contribution to Fertilizer Development in Africa (Summary) and Fertilizer Handling in African Ports," Paper presentation at FAO/FIAC Conference, Rome Italy, April 12, 1989. Norsk Hydro, A.S., Oslo, Norway.

Williams, L.B. "Development of an Agrochemical Industry in Africa." Paper presented at seminar "The Role of Chemistry in Improving Food Supplies in Africa" in Nairobi, Kenya. July 1988. IFDC, Muscle Shoals, Alabama.

World Bank. 1988. *World Development Report 1988*, Oxford University Press, New York, New York.

Seed Industry Development Strategies[1]

*Johnson E. Douglas**

Seed industry development strategies used in newly emerging seed programs during the last 30 to 40 years have differed greatly. Some of these strategies were far superior to others. The challenge today is to identify the most successful strategies and apply them effectively in renovating floundering national seed programs.

The term "seed industry" refers to the entire complex of organizations, institutions, and individuals associated with the seed program in a country. Although one of the most critical strategy decisions relate to the development of the "commercial seed industry", the strategies for several related components can significantly affect the seed industry. Components of the seed industry for which strategies are critical relate to a government's mechanisms for providing leadership; crop research; breeder, basic, certified, and other commercial seed production; seed quality assurance and control; extension; seed marketing; seed technology personnel development; and resource allocation.

The Strategic Importance of Seed

Successful seed industries develop when governments recognize the importance of seed in agricultural development and act upon that decision. As a result, a high priority is placed on assuring strategies are identified and implemented that stimulate the development of the seed industry. Since the seed industry includes several groups that must work in harmony toward common goals, a mechanism is required to provide a forum to assist the decision making process. With such a mechanism these groups can agree on strategies, develop necessary goals and policies to support the strategies, and assure that the desired results are achieved.

Steps are needed by governments to form such a forum--often called a National Seed Council (NSC). Assuming the private sector is to play a role in the seed industry, it must be well represented on such a Council. The NSC should assist in developing strategies appropriate for the country's needs, help maintain a high priority on the development of the seed industry, and monitor developments to assure consistent growth. Key strategies that require consideration at the national level and by a NSC follow.

Crop Research and Seed Strategies

A dynamic seed sector can only develop when suitable improved varieties and hybrids are constantly streaming from crop research programs. To accelerate varietal improvement, strategies are needed that strengthen in-country crop research, stimulate cooperation among crop research programs in

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the region, and maintains strong links to international agricultural research programs. Although most research is done in this region by the public sector, long-term strategies are needed on how public and private research programs can cooperate. These developments are important to the commercial seed industry since they can increase the availability of improved varieties and hybrids that can be made available to farmers and sold in the region. Strategies that assure cooperation in crop research benefit everyone--especially farmers.

Similarly, public sector crop research programs require strategies focused on developing a vigorous seed industry to move the results of their work to farmers. They need a strategy that outlines their supporting role for other parts of the seed industry after improved varieties and hybrids are developed. Going beyond germplasm improvement, this role includes: 1. assuring simplified variety release and introduction procedures, 2. providing adequate descriptions of varieties to assist the seed multiplication process, 3. operating a suitable maintenance system for varieties and inbreds, 4. assuring adequate supplies of breeder seed, 5. assisting with foundation seed supplies, 6. contributing to allocation procedures for foundation seed that stimulate the private sector, and 7. utilizing a storage system for breeder and foundation seed to assure continued and adequate supplies of these seed. Cooperation is essential between the crop research program and the commercial seed industry!

Strategies for the Foundation Seed Program

Foundation seed, or its equivalent, is the bridge between the research program and that portion of the seed sector that multiplies and supplies seed to farmers. Clear strategies for assuring the rational development of this phase of the seed industry are often lacking. The most successful foundation seed programs have resulted from special projects or autonomous units that have the means to consistently deliver adequate supplies of foundation seed to the commercial seed industry regardless of the financial situation of the government. These programs have administrative autonomy and flexibility. Some financial autonomy from government improves operational efficiency and contributes to the ability of the program to achieve partial or total financial self-sufficiency.

Political decisions are needed to assure that the program is officially recognized and structured for long-term growth. Guidance by an advisory committee or board is highly desirable. Well defined goals and responsibilities are vital. Also needed are well trained personnel, adequate infrastructure, continuous sources of pure breeder seed, and effective quality assurance and control programs.

Decisions regarding the individuals and organizations that receive foundation seed has a significant influence on how the commercial seed industry develops. Seed allocations are most needed the first year a new variety or hybrid is introduced. The allocation system can encourage or discourage seed

growers and enterprises to join the seed industry. Specific criteria must be developed to determine to whom seed is to be allocated and on what basis.

In addition to developing strategies that assure the above basic requirements are met, the strategy of using the foundation seed program as a tool for assisting the development of the commercial seed industry should be considered. The foundation seed program can help identify and start new seed growers and enterprises. The staff can provide technical assistance for them. Special programs could be developed to provide small-scale seed drying and conditioning equipment on a lease-purchase arrangement to new, small seed enterprises through the foundation seed program. Other specialized supplies might be made available through the program. Pre-release seed multiplications could be done to accelerate the introduction of new varieties. Breeder and foundation seed reserves in excess of normal operating needs could be held to meet emergencies with special funding because of the development nature of such a program.

As a key strategy in seed industry development, forming and operating an effective foundation seed program is vitally important.

Strategies for Developing the Commercial Seed Industry

The lack of clear strategies for developing the commercial seed industry is a weak link in many seed programs. In the early stages of programs several countries have tried the national seed enterprise approach. This strategy places too much responsibility in one organization; and if difficulties are encounteres, the whole of the national seed supply is in jeopardy. Today, more and more countries are evolving strategies that place an increased emphasis on developing numerous seed growers, enterprises, and sellers who catering to local needs.

Strategies that encourage the development of these seed growers, enterprises and sellers in the private sector require high level political decisions and supporting policies to be successful. Many countries have been successful with this strategy. Most countries in Latin America have moved in this direction during the last 20 years. Today 92 percent of all maize seed is sold by the private sector in that region. Successful examples also exist in Asia. Several countries in Africa are at the point of experimenting with innovative ideas to achieve this objective.

With this strategy it is important to recognize that small, medium, and larger seed enterprises can coexist in a competitive environment. Some extremely small seed producing/selling units are operating in several countries such as Colombia, Guatemala, Nepal, and India. These operations are organized in many different ways ranging from family businesses to cooperatives of many small farmers.

Mechanisms often are needed to provide favorable credit for modest capital investments and working capital. Tax incentives frequently are provided, as the seed business can be considered a priority industry that receives special benefits.

Other incentives include the availability of foundation seed supplies and of germplasm in the case of an enterprise that may chose to undertake some plant breeding on its own. Import privileges for selected seed stock and germplasm can be helpful. Technical support from the crop research program, extension, and the foundation seed program is quite important.

Even when a significant investment has been made in a public sector seed enterprise, such an enterprise can be modified and used to facilitate the development of a decentralized, private-oriented system. Existing facilities can be divided and leased to smaller groups catering to local needs. Facilities can be sold on favorable terms or operated jointly as a public/private partnership. Custom seed conditioning can be provided for new enterprises until they can arrange for their own facilities.

If this strategy is to be successful, seed prices must be at a level that growers, enterprises, and sellers are all stimulated to participate. Public and private organizations have operated in a competitive atmosphere when all costs of production, conditioning, storage, and marketing are included in the preparation of the price structure. Of course, some profit must also be possible or investments will not be made in the commercial seed industry.

A long-term commitment to such a strategy is required. Developing a commercial seed industry from the "grass roots" level takes time; but if incentives exist and a few successful "seed pioneers" get started, many will follow.

Strategies for Quality Assurance and Control

The need for good quality seed is well accepted. How to reach this goal is the basic question. Many alternatives exist and the strategies developed should facilitate the use of more than one alternative.

Since much of the seed planted is the farmer's own seed, an emphasis is needed on how the quality of that seed can be improved. To do this requires an understanding of what the farmer now does and the development of better methods that can be applied easily.

As seed growers, enterprises, and sellers are started, they must be encouraged to develop their own *internal quality assurance* programs. It is logical for them to place a strong emphasis on seed quality because their reputation and future seed sales depend upon the quality of their product. A strategy that places as much reponsibility as possible on the commercial seed industry for seed quality greatly simplifies the public sector's role and can help keep the system free of highly bureaucratic, restrictive procedures.

The public sector has a major role to play in developing strategies and programs that achieve the two earlier objectives. In addition, some from of *external quality control* is needed. The most common methods include a seed certifying system and the control of quality at the marketing stage.

Seed certifying systems are the most recognized and widely accepted method for maintaining genetic identity and purity of improved

varieties and hybrids. Quality control is also concerned with assuring high germination of seed at time of sale and selling seed that is free of soil-borne diseases and weeds. Although the objectives are noble, wide differences exist on how well these programs operate. Especially in newer programs, an emphasis is needed on education and development. The program should be offered as a service to be used voluntarily--not on a mandatory basis. The staff of these programs must be well trained, mobile, and sensitive to the needs of seed growers and enterprises. Fees normally are collected for the services provided, so these programs can become partially or totally self-sufficient financially in the long-term. The unique nature and role of this system should be recognized, so it is formed in a way that it can achieve its goals.

Quality control at the marketing stage can help improve the quality of all seed sold and is a simple program to initiate and administer. The Food and Agriculture Organization (FAO) recently outline a "Seed Quality Declared" program that is similar in nature to quality control at the marketing stage. These programs place an emphasis on the proper labelling by officials to assure that the seed has been labeled correctly and/or meet certain levels of quality. Seed quality education is an important ingredient of this program also.

Improved seed quality must receive a high priority in any program, but the strategies developed should incorporate a range of methods and recognize that both the private and public sector can contribute much to achieving the goal of better seed for more farmers.

Strategies for Getting the Seed Used

Extension in Support of Seed Use-- Extension workers can play a significant role in reaching seed users. Their knowledge of varieties and appreciation of the value of good seed, when combined with an effective use of extension methods, make extension specialists a vitally important part of the seed industry.

The needs of the seed industry today require strategies that enlarge the extension specialist's role. Assistance is required in the identification and development of local, small-scale seed producer/sellers and seed enterprises. The assessment of the quality of seed now saved by farmers, or their wives, for their own planting can be done by extension workers. Improved methods can be developed for the farmer to save his own seed in cooperation with research personnel. Special educational programs on seed quality are an extension responsibility. Although these tasks need to be done by the general extension specialist, the development of a few "Seed Extension Specialists" could greatly strengthen this aspect of the program and more closely link the extension program with the seed sector and researh.

Seed Marketing to Reach the User--The extension specialist's responsibilities are too great for this person to be concerned with seed marketing. The stragy should be to strengthen the commercial seed industry and encourage the development of many retail outlets for seed. Successful seed enterprises have hundreds of seed sellers linked to them. Seed sellers could include a wide range of marketing enterprises,

local shops, fertilizer and agro-chemical outlets, and leading farmers. These seed sellers must know their product and have incentives to sell. Training programs for them are an essential part of any strategy to increase seed sales. Various incentives in addition to commissions have been used to stimulate seed dealers to sell more. Contests, bonuses, prizes and free trips are frequently used by the hybrid maize seed industry in the U.S.A. and similar techniques have application with adaptation to developing programs.

Seed dealers are an extremely vital part of any market intelligence program. The dealers can be valuable sources of information when properly used to forecast market needs and identify areas of potential expansion. As their reports are combined with general economic, crop, and variety trends plus information from the extension and research programs,the means are available to more accurately predict seed needs and expand markets. Research and extension programs are mentioned again here to stress the vital importance of the commercial seed industry working as partners with them in order to reach more users.

Increasing seed usage does not just happen! Strategies that combine the best efforts of the research program, the extension system, and the commercial seed industry must be formulated and implemented to be successful.

Personnel Development and Training Strategies

No list of strategies for seed industry development is complete without assuring that a strategy exists for improving the human element. Too often more attention is given to physical resources, such as seed conditioning and seed testing laboratories, than the development of people to operate them.

Personnel development and training strategies should start with an assessment of people with good training and experience today. Some of these people could be future leaders of new seed enterprises, quality assurance and control programs, marketing programs, and special extension efforts on seed.

A national seed training plan should be developed by the NSC. The plan should identify the kinds of training needed and determine to what extent the training can be provided locally. If the desired training cannot be done locally, consideration should be given to what is available in neighboring countries or the region. Finally, training in developed programs outside the region should be considered. A person should be in charge of organizing and coordinating local training.

Then the basic strategy should be to identify people who have good potential and are interested in the seed industry, provide them with adequate training, and assure that they are in positions that properly utilize their skills and ability. The most successful seed industries have people who are highly motivated and well trained.

Strategies for the Development and Utilization of Resources

In addition to human resources, physical and financial resources must be a part of the seed industry. When the strategy for agricultural development places a high priority on the seed industry, the needed physical and financial resources must follow. Unfortunately, in the interest of assisting the seed industry the physical resources such as seed farms, seed conditioning facilities, and seed laboratories can become more sophisticated and grandiose than are actually needed. The strategy developed should concentrate on a decentralized seed production system with equipment that is as easy to operate and maintain as possible. Seed farms are often not needed because seed can be grown under contract with private growers at a lower cost. Many countries find seed farms a burden and costly to operate.

The financial requirements of the commercial seed industry are unique because of the high ratio of working capital required compared to equity capital. Banks and local lending institutions need to develop lines of credit with favorable interest rates that accommodate these requirements. The public sector should develop strategies that can help the commercial seed industry grow through the use of credit.

As discussed earlier, after the initial investment in equipment and facilities, the strategy for the foundation seed program and the seed certify system should be to help them to become partially or totally self-sufficient financially. To achieve this step requires special consideration and a rotating fund in which revenues can be held for future need.

Maintaining Consistent Strategies

Seed industries suffer from the inability to maintain consistent strategies with the needed supporting policies to achieve them. Changes in governments and the personnel in the government and the seed industry are primarily responsible for this difficulty. One of the main advantages of a NSC, if it is properly organized and used, is that it provides a structure through which greater continuity can be achieved.

Seed legislation, if carefully drafted, can provide continuity of strategies and policies. Legislation can clarify the role of the public and private sectors. It can provide the legal base for the release and use of varieties, the foundation seed program, seed certification, and/or seed marketing quality control. The standards and procedures used in these quality control programs can be included in supporting regulations. These measures help to provide consistency and continuity in the program.

As the private commercial seed industry becomes established, many people become familiar with the managerial and technical requires of a seed system. The seed growers, enterprises, and sellers tend to remain with the program from year to year when suitable incentives exist and considerable continuity of personnel and institutions is achieved.

When an ongoing training program is established, many people are receiving the same kind of information and communication becomes easier among all involved.

As the program develops, the formation of seed trade and/or technology associations improves communication among people involved in the program and contributes to increased continuity of effort.

Conclusion

Many alternative courses exist for seed industry development. The strategies selected can spell success or failure. The successes that exist among many countries can be used in selecting strategies that are the most successful. Countries are in different stages of development. The basic strategies outlined only need to be adapted and matched with the particular stage that exists today.

Now is the time to move dynamically in selecting the strategies that can result in the first class seed industry needed to better serve all farmers.

References

Bentley, F., R. Griffiths, and G. Reusche. 1986. Improved Seed Systems for Africa. Winrock International, Morrilton, Arkansas.

Beck, D.L. 1987. An Evaluation of the Seed Production System in Ghana. CIMMYT, Mexico.

Brown, M.L. 1982. Some World Bank experience in financing seed projects with special reference to Asia. A paper presented at the CIAT Workshop on Improved Seeds for Farmers with Small Holdings, August 9-13, 1982, Cali, Colombia.

CIAT. 1986. Memorias--Semilla mejorada para el pequeño Agricultor. CIAT, Cali, Colombia. September 1986.

CIMMYT. 1987. 1986 CIMMYT World Maize Facts and Trends: The Economics of Commercial Maize Seed Production in Developing Countries. CIMMYT, Mexico, D.F.

CTA and IAC. 1985. Proceedings of the Seminar on Seed Production. Yaounde, Cameroon. October 1985.

Douglas, J.E. 1986. Alternatives to Strengthen the Seed Sector in Developing Countries. CIAT, Cali, COlombia.

Douglas, J.E. 1984. Successful Seed Development Experiences. CIAT, Cali, Colombia.

Douglas, J.E. 1980. Successful Seed Programs: A Planning and Management Guide. Westview Press, Boulder Colorado.

Groosman, A., A. Linnemann, and H. Weirema. 1988. The international dimension of seed industry development. A paper presented at the seminar on Technology Development and Changing Seed Supply Systems, Tilburg, The Netherlands. June 22, 1988.

McMullen, N. 1987. Seed and World Agricultural Progress. National Planning Association. Washington, D.C.

Van Gastel, A.J.G. 1988. Stimulation and Development of National Seed Production Organizations in West Asia and North Africa. ICARDA, Aleppo, Syria.


MAIZE

Shaping Maize Germplasm to Local Requirements: The National Program Imperative

*Ronald P. Cantrell**

At various times in its history, Ghana has occupied the flattering, if not easy, position of being a pioneer. Upon gaining independence in 1957, Ghana was the first of the new African nations to experiment with development strategies that were popular at that time. It was the focus of much international attention and the subject of many studies of development experience. Now, Ghana is in the limelight once again, primarily because of the initial success of its economic recovery program but also because of current efforts to confront problems in the production of its major food crops.

On the food production front, Ghana is faced with a number of difficult questions. And the way they are addressed now will affect the course of food crops research and production for many years to come. Some of the fundamental issues are these: What types of assistance can Ghana count on from international institutions? What resources can be mobilized within the country? And, most important, what is the best strategy for putting national and international contributions to work for the nation's farmers? These are, of course, extremely broad questions and relate to all of Ghana's food production enterprises. My remarks will deal only with maize research, emphasizing germplasm development in particular.

Briefly, my views on the issues raised above, as they relate to maize germplasm development, are as follows. Owing to some 15 years of international cooperation in maize breeding, Ghana now has a solid germplasm base and is skillfully exploiting this material to meet farmers' needs. Moreover, many additional maize germplasm products are being developed at CIMMYT, IITA, and other institutions. And these materials will provide Ghanaian maize breeders with new opportunities to improve their skills and offer farmers better products than the ones available now.

Unlike the consumer goods that a country might acquire from abroad, germplasm products supplied by the international centers and other sources generally require a certain amount of local adaptation. While that is being achieved, the germplasm component must be combined with improved crop management practices through experiment station and on-farm research. Then come the tasks of large scale seed production and on-farm demonstration. Carrying out these critical operations requires a core of talented, dedicated people who are capable of building sound agricultural institutions. In Ghana the germplasm and other technology components are there, and capable

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people and institutions are gradually coming into play. The difficult task is essentially one of organization: to maintain an efficient, long term process, with strong government support, by which the technology components can be assembled into packages of improved agricultural technology.

About CIMMYT

Before expanding on these themes, I would like to make a few comments about CIMMYT. The Center contains three research programs: Maize, Wheat, and Economics. These, along with various support units, are staffed by about 140 scientists and other specialists. Roughly half of the scientists work out of offices at 17 locations around the Third World. The rest are stationed at our headquarters in Mexico.

Support to National Programs--Most of our efforts are channeled into three forms of support to national agricultural research systems. First, we provide technology components, chiefly maize and wheat germplasm, for major production environments in the Third World. Second, we develop more efficient methods for plant breeding, crop management research, and agricultural decision making, frequently through direct collaboration with national programs. The third form of support--training and consultation--is our primary means of helping tailor germplasm and methods to the circumstances of particular regions and national programs. This is also our main contribution to strengthening the capacity of national programs to mobilize their own resources as well as those provided by CIMMYT and other institutions.

The Mega-Environments Concept--How are CIMMYT's products and services apportioned in sub-Saharan Africa? We disseminate germplasm, mainly in the form of broadly adapted experimental varieties, through an international testing network, in which some 24 African nations take part. As participants in our germplasm distribution scheme, African researchers can draw upon the combined experience of colleagues, not just on this continent, but in maize producing countries worldwide. Admittedly, it is not easy to imagine how maize breeding in Mexico or Thailand can be relevant to Ghana or Zambia. But our global operations do make sense in the framework of what we call the mega-environments approach. This is a scheme for classifying and documenting the Third World's numerous and diverse maize growing ecologies.

We define a mega-environment as an area of no less than a million hectares throughout which a given type of germplasm is adapted to prevailing conditions. The conditions we take into account include broad climatic features, maturity time, moisture requirements, pests and diseases, and consumers' grain preferences. Any point at which the germplasm is no longer suitable marks the discontinuation of one mega-environment and the beginning of another. Mega-environments are frequently transcontinental, encompassing "pockets" of production that may be

separated by thousands of kilometers. Thus, a lowland tropical area of Guatemala, where farmers grow late maturing, white dent maize, may be very similar in its basic germplasm requirements to a corresponding area of Ghana. What this means is that a Ghanaian breeder can profit from maize improvement and trials conducted by Guatemalan colleagues and vice versa. Such possibilities are a tropical version of what has happened with US Corn Belt germplasm. With little or no difficulty, that material was transferred to the temperate zones of Europe and later China and had the same explosive impact on maize yields.

If only the story of tropical maize were that simple! What complicates it is that there are marked differences in disease pressures between tropical regions of the Third World. Consequently, the Guatemalan and Ghanaian breeders cannot use exactly the same version of a given maize population. Lowland tropical germplasm for the Guatemalan breeder must have resistance to the corn stunt virus, and that for the Ghanaian breeder needs resistance to maize streak virus, which occurs only in Africa. To bring about these regional adaptations in lowland tropical material, we have engaged in a series of cooperative breeding projects with other international centers and national programs. One of these was a project initiated at IITA headquarters in Nigeria during 1980. Our joint efforts generated a large collection of broadly adapted, streak resistant germplasm that is well suited to many African environments.

Worldwide, we have identified about 25 mega-environments for which CIMMYT can justify a significant breeding program. Most of these are represented in sub-Saharan Africa, and 3 occur in Ghana. (**Table 1**). All of the information on which we base the mega-environments approach is supplied to us by our research cooperators in developing countries. From their data we develop country maps, which are accompanied by tables indicating the estimated extent of the various mega-environments and the main features that distinguish them. We are also developing maps that show the mega-environments across continents.

Table 1. Maize Mega-Environments in Sub-Saharan Africa

Identifying features (germplasm requirement)	Estimated area (million ha)
Lowland tropical	
Early/extra early	2.03
Intermediate	1.60
Late/extra late	3.60
Subtropical/midaltitude	
Early/extra early	0.13
Intermediate	2.30
Late/extra late	4.20
Highland transitional	
Early/intermediate	0.07
Late/extra late	1.50
Total	15.43

Note: For the purposes of priority setting in CIMMYT's maize improvement programs, the categories listed here are further subdivided according to various combinations of grain color (white or yellow) and texture (dent of flint).

Regional Programs--Mega-environ-ments data supplied by national programs are initially compiled by staff of CIMMYT's regional programs. There are two of these in sub-Saharan Africa. One covers the eastern region and is based in Nairobi, and the other, with its office at Harare, is for southern Africa. In addition to conducting research, our regional staff organize in-country training, consult with national researchers about their maize research and training needs, and help design programs for meeting those needs. The southern Africa program is also developing midaltitude maize germplasm.

Bilateral Projects--In addition, CIMMYT has been involved in several bilateral projects in Africa. From 1972 to 1981, we had two staff based in Zaire. During 1973 to 1983 we worked with IITA scientists on a project in Tanzania. And since 1979 we have participated in the Ghana Grains Development Project (GGDP), which is funded by the government of Ghana and the Canadian International Development Agency (CIDA). Under this project CIMMYT is cooperating with various national institutions--the Crops Research Institute (CRI), Grains and Legumes Development Board (GLDB), and the Ministry of Agriculture (MOA). IITA is involved in the research on cowpea and other legumes.

The Ghana Grains Development Project

The Grains Project has been one of the most positive and instructive experiences in the Maize Program's 23-year history. The Project's plant breeders have developed six improved maize and four cowpea varieties for release to farmers. Its crop management research has produced comprehensive recommendations for production of these crops. And a recent adoption study suggests that the recommended varieties and production practices are being accepted by farmers. These individual achievements are highly significant in themselves. But what we find most exciting about the Project is the process by which the varieties and practices came into being. Details are provided in a recent issue of our CIMMYT Today series, and copies are available at this meeting. Here I will outline a few key features of the Project's technology development process that account in large part for its success.

From the start a central assumption of the Grains Project was that appropriate agricultural technology, ready for adoption by farmers, cannot be imported. It must be developed within Ghana, largely by Ghanaians. The role of the international centers has been to provide some of the components of this technology and assist in the development and testing of research methods.

Training--A precondition for this approach was extensive training at all levels, including graduate studies; in-service courses offered by CIMMYT, IITA, and other institutions; and in-country training, mainly for extension officers. Ghana already possessed a sizeable pool of talented people who had been trained by the country's universities, government agencies, and previous development projects. With the Grains Project's additional investments in training, the country has gained a core of capable

researchers in various disciplines, reliable technicians, and motivated, well-informed extension officers. Moreover, by creating a solid in-country training program, the Project established a mechanism for helping to continually upgrade the country's extension network.

Links between Groups--The Project's research is organized around a few major commodities and the various farming systems in which they are grown. Staff work in multidisciplinary teams and distribute their time and resources between experiment station and on-farm activities. The on-farm work provides a vital point of contact between researchers, extension officers, and farmers that directly benefits each of these groups. Researchers at CRI get regular feedback on the performance of the technologies they are developing. Extension officers with the Grains Board and Ministry of Agriculture become more knowledgeable about the details of ongoing research and achieve greater credibility in discussing new technology with farmers. And the farmers become important actors within a system that allows them to test technology themselves and offer their own opinions. The growing links between these groups are what sharply distinguishes the current situation of maize and cowpea research in Ghana from the status quo in many developing countries.

Sasakawa-Global 2000--An additional source of encouragement is that the Sasakawa Global 2000 Project is disseminating some technologies developed at CRI much more widely than was possible before. In addition, it is dealing with some of the conditions that reduce the impact of improved technology, such as limited availability of improved seed, fertilizer, and credit. Apart from its immediate benefits to farmers, this work is helping set the stage for integrating the goals of efficient food production and a prosperous rural sector more fully into the nation's overall economic planning.

Germplasm Products for National Programs

In this section I will review quickly the germplasm products available now, others that will be ready in the near future, and a few whose development will take at least another 10 years. In doing so I will comment on ways in which Ghana and other African countries have already employed some technology components from the international centers and suggest ways in which they could exploit the germplasm products of the future. The point I want to emphasize about germplasm products obtained from CIMMYT and other sources is that they have only potential value. Their worth cannot be realized unless the national program is capable of assembling these components, along with other elements, into finished technologies for farmers.

Broadly Adapted Maize--The largest category of germplasm products available now consists of broadly adapted open-pollinated materials. Many of the maize varieties released in Ghana and other African countries were developed from experimental varieties provided by CIMMYT or IITA or with materials extracted by national programs from the centers'

maize populations. Much of this germplasm is now being further refined at the regional and local levels. The Ghanaian variety 'Okomasa', for example, before its release in 1988, was converted to streak resistance by the CIMMYT/ IITA program in Nigeria. In addition, Ghanaian breeders are improving all the materials in their program for husk cover, which helps reduce infestation by ear rots and storage pests and thus provides farmers with a more satisfactory product.

Quality Protein Maize-- Ghanaian breeders are working with other germplasm products available now whose benefits will not become apparent for a few more years. One project in which breeders are definitely in the company of pioneers is their work on quality protein maize, or QPM. This material, the product of a long term breeding program at CIMMYT, possesses the mutant opaque-2 gene, which increases the content of two essential amino acids in maize by about 50%. Ghana's experience with QPM will provide an important test of 1) its nutritional benefits for people and their animals, 2) the skill of national programs in manipulating this special germplasm, and 3) its performance in farmers' fields.

Hybrid Maize--In another forward looking move, Ghanaian breeders recently began a modest hybrid development program. CIMMYT can assist by providing information about the utility of our materials in hybrid formation, along with special products, such as populations that are tolerant to inbreeding. IITA is also in a good position to help, since it has developed hybrids successfully for the lowland tropics. The recent experience of a Nigerian seed company, Agricultural Seed Ltd., suggests that the distribution of hybrid seed to small scale farmers can be organized effectively and that these farmers are willing to give hybrids a try.

Special Purpose Populations-- Obviously, the germplasm "on the shelf" now continues to offer opportunities for increasing the quantity and quality of maize production in Ghana and other African countries. Nevertheless, this material is deficient in several traits, such as drought tolerance and insect resistance, that would provide the African farmer with added insurance against catastropic crop losses. For that reason we at CIMMYT are working on a whole new generation of products called special purpose populations, with the intention of having them available in three to five years. What is special about these populations is that they possess high levels of resistance to one or a few biotic or abiotic stresses. The first of these materials to reach national programs will be a tropical population with resistance to various corn borers, a drought tolerant population, and a semiprolific material with good general stress tolerance. We also expect to have germplasm that is tolerant to aluminum toxicity for countries, like Malawi and Zambia, that have some acid soils. In addition, both CIMMYT and IITA should be able to provide striga resistant materials in the near future.

As the special purpose populations become available, we will send them first to larger countries, such as Brazil, China, and India, whose national programs are fully prepared

for the somewhat complex handling of the resistance sources. Meanwhile, in our own breeding program, we will be transferring the resistances from special purpose germplasm to a number of broadly adapted populations, which will be suitable for distribution to a much larger group of national programs. In addition to receiving resistant germplasm from CIMMYT, breeders in many Third World countries can adopt techniques for improving resistance in the materials they already have. Our physiology program, for example, has found recently that drought tolerance can be improved through a straightforward procedure of selecting for a narrower anthesis-silking interval.

Biotechnology

Before closing I would like to describe a couple of promising developments in biotechnology that have implications for maize breeding. We at CIMMYT estimate that products of this work will be available to developing country farmers in another 10-15 years.

Maize Endophyte System--One of the most exciting recent discoveries is a bacterial gene responsible for producing a substance that kills European corn borers. This gene can be transferred to a maize endophyte, which is a microorganism that occurs naturally in maize plants. The genetically transformed endophyte is inoculated into maize seed and at some point during maize development begins producing the substance that kills attacking borers. This technology was developed by a private company in the USA and is currently being tested by various North American seed companies. They claim that it will be cheaper than insecticide application and environmentally safer. We are curious to know whether this technology is also effective against borer species found in developing countries. But at present it is impossible for us to investigate this question, since the technology is in the hands of the private sector.

RFLPs--We have been more successful in gaining access to techniques involving the use of DNA probes, such as restriction fragment length polymorphisms (RFLPs). After reviewing a whole range of techniques, we decided that this approach offers the widest range of immediate applications and the most promise for increasing efficiency in maize improvement. Already, numerous markers are available that make it possible to identify, map, and select genetic regions in maize that control important quantitative traits, like insect resistance or drought tolerance. With genetic markers, selection for these traits could be done more rapidly and efficiently through laboratory analysis of leaf samples. As a start toward trying out this technology, CIMMYT has become involved in four RFLP related projects. In the most extensive of these, we are cooperating with a network of public and private organizations in Europe.

Conclusion

The exciting prospects of biotechnology seem very remote from the more mundane world of conventional maize improvement. But in fact, biotechnology is not a substitute for traditional plant breeding methods. It merely promises to greatly extend their powers and increase their efficiency. The use of RFLPs, for example, does not mean that plant breeders can trade their muddy boots in for lab coats. After all, there have to be experimental plots from which to take the leaf samples. And when laboratory analysis shows the presence of resistance, this has to be confirmed through field testing. Nor will the role of national programs be altered much over the next 10 years. About the only difference is that they will get technology components, like the drought tolerant populations I mentioned before, far more quickly. They will still have to adapt this germplasm locally and fit it into a technology package.

So, even as we work to fulfill the promise of biotechnology, Ghana and other developing nations will face essentially the same challenge they are confronting now. And that is to build strong national research programs capable of providing farmers with appropriate technology. CIMMYT will remain at the periphery of this work, providing technology components and improved research methods. We hope that donor organizations will be able to make long term commitments to sub-Saharan Africa and apply effective strategies for strengthening its agricultural research and extension systems. Then, perhaps, when the products of biotechnology finally do arrive, someone will be at the experiment station to meet them.

IITA Agricultural Research and Technology Development with Special Reference

*Laurence D. Stifel**

Twenty-two years ago, long before sustainability became a burning issue, the founding fathers of IITA had a vision of a new institute in Africa. It was established to increase the productivity of key food crops and to develop sustainable agricultural systems that could replace bush fallow, or slash and burn, cultivation in the humid and subhumid tropics. IITA's mandate reflects both the essential difference and the critical link between the goals of feeding hungry people and developing sustainable systems.

Our founders recognized that the major advances in temperate agricultural technology in recent decades were not well suited to the resource-poor farmers of tropical Africa. To serve these people, scientists had to recognize the diversity of farmers' conditions and to understand the crop production systems that had evolved with them over hundreds or even thousands of years.

This farming systems orientation distinguishes IITA from the international centers which concentrate upon a single or several commodities. The complexity of this responsibility compels us to seek focus and integration in our research program. This focus has four dimensions. First, concentration on African smallholders or family farmers. Second, focus on the improvement of the farming systems of the lowland humid and subhumid tropics of West and Central Africa. West and Central Africa account for the greater part of such lowland environments in all Africa, and this geographic focus is consistent with the international character of IITA. The third aspect is focus upon the most important agro-ecosystems of West and Central Africa. IITA is situated in the narrow transition zone between the two major environments of the region, the humid forest and the savanna. We are decentralizing our research to small substations in these two major ecological zones of the region.

The fourth dimension of IITA's focus relates to the scope of commodity improvement research where critical choices are necessary to determine how many commodities and which commodities to include in our agenda, given the limitation of resources and the need for a critical mass of scientific effort for success. IITA currently conducts commodity improvement programs on cassava, cowpeas, yams, soybeans, plantains and maize. I have been requested to direct my remarks to the technology available for cassava and cowpeas. Before doing that however, I believe that it is important to clarify IITA policy concerning maize improvement research in Africa.

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IITA was one of the original four international centers, the first to be established in Africa, and the largest and most comprehensive of the CG centers in this continent today. In the 1970s, many of the centers located in other regions expanded operations in Africa in response to the complexity of African agriculture and the growing food crisis here. Today about 50% of the scientists in the CGIAR system are working in Africa. The formal mandates of the centers, which were established over a period of two decades, are potentially conflicting, and the burden rests primarily upon the centers themselves to work out effective modes of collaboration to harmonize their work in Africa.

In the case of maize, CIMMYT has the global mandate and IITA has an African mandate for maize improvement research in the lowland tropics, the agro-ecology located primarily in West and Central Africa. Several years ago, we developed a collaborative maize research agreement with CIMMYT that accords leadership to IITA for maize research in West and Central Africa and to CIMMYT for East and Southern Africa. At that time, CIMMYT was engaged in the successful Ghana Grains Development Project in Ghana concentrating primarily on maize. CIMMYT requested permission to continue this project during its final phase, after which IITA would assume primary responsibility within the CGIAR system for strengthening maize research in Ghana. IITA agreed to this request. Because so many leaders of national agricultural research and development systems are at this meeting, I thought it necessary to clarify that this is an exception to the CGIAR policy agreed upon for this region.

Since the technology we generate is of little value for countries lacking the capacity for effective utilization of it, IITA assumes the responsibility to assist in building such capacity. This is particularly important in West and Central Africa, where over half the countries spend less than $3 million annually on agricultural research. The goal of IITA's international cooperation activities is to strengthen the capability of national agricultural research systems to use and generate agricultural technology in order to satisfy their own needs. IITA has the largest portfolio of special projects to develop partnerships with national programs in the CGIAR system. This has enabled us to engage in a wide range of collaborative activities to extend technologies to specific agroecological zones thus contributing to national systems throughout Africa. Since 1971, IITA has trained more than 5,000 Africans, from technicians in group courses to scientists conducting research training for postgraduate degrees. The Institute's scientists work with IITA alumni who are now in key positions of responsibility in African national systems.

The first commodity I will discuss is cowpeas. IITA has global responsibility in the CGIAR system for cowpeas. West Africa is the center of origin and genetic diversity of the crop, as well as the world center of production. IITA has long standing, strong cowpea improvement program, linked with national program scientists in developing countries and with centers of advanced research in the

developed countries. IITA also holds the world collection of cowpea germplasm on behalf of the CGIAR.

Cowpeas are chiefly important in the sorghum and pearl millet farming systems of the semi-arid zones, although their cultivation extends into the lowland humid tropics of Africa and other continents. As a nitrogen-fixing crop with high protein content, cowpeas are an important component of sustainable mixed cropping systems in large parts of West and Central Africa.

The IITA research program for cowpea improvement focuses on important pest and disease resistance. There was a change three years ago from the past policy of breeding varieties for grain production as sole crops using insecticides to control pests. Although this has been an outstanding success, it is dependent on the cost and availability of insecticides and sprayers, and it is likely that the majority of cowpeas in Africa will continue to be grown by resource-poor smallholders in intercrop mixtures with cereals. In addition, breeding objectives need to take into account production of the haulms, which are a principal source of animal feed in most of the cowpea growing regions of West Africa. Thus, the major thrust of present research is to breed varieties that are well-adapted to the cereal farming systems of the African savannas and that meet the dual needs for grain and fodder.

IITA has succeeded in developing varieties resistant to some important insect pests, of short duration and with a diversity in seed color and plant type to meet diverse consumer requirements. Efforts to develop advanced breeding lines for national programs have been continuous and target oriented. In Ghana for example, four new cowpea varieties have been released and they are spreading. The seed agencies have increased production from 1 ton to 30 tons the past three years. Their yield, with improved management but no fertilizer, is 100% greater than traditional varieties. The improved varieties require less spraying with insecticides because of their short duration and partial resistance. The cash cost of spraying is only a small fraction of the value of the increased output.

Cowpeas are an important element in the sorghum systems being promoted by the Sasakawa Global 2000 project in Ghana. We believe these improved cowpea varieties have reached a stage for active promotion to the extension services. In the medium to long term, partly through biotechnology, we expect major breakthroughs in our research to reduce dependence upon chemical spraying, but we cannot wait for specific perfection before improved cowpeas are made available to farmers. As Dr. Norman Borlaug warns, we are in a race against time with the population monster.

We therefore suggest that IITA cowpea scientist in Ghana, Dr. Hossain, collaborate with Global 2000 next year to add the second major component, cowpeas, to the sorghum-based farming systems of northern Ghana.

The second commodity to be discussed is cassava, and I shall start by citing two facts reported to the workshop by Commodore Obimpeh, Secretary for Agriculture of Ghana. During the last year the major source of increased food production in Ghana was roots and

tubers, primarily cassava, and the Ghana national agricultural plan targets a doubling of the average yield of cassava over the next five years from an average of 5 tons to 10 tons per hectare.

Cassava is the chief source of food energy for the majority of people living in the lowland humid tropics and much of the subhumid tropics of West and Central Africa, providing more than two and a half times as many calories as either maize or yam, the next two most important staple foods in the region. The importance of cassava is likely to grow further, both because of advancing urbanization, and consequent demand growth for foods prepared from cassava, and because of population pressure to cultivate marginal lands. Cassava's ability to be more productive on poor soils than most other crops has been a major factor in its spread and increase, especially in the low nutrient and often acidic soils of the humid forest zone. Its husbandry also requires relatively little labor and allows flexibility in the timing of labor use, which is of great importance whenever labor constraints are significant. Cassava also tolerates drought and recovers well from leaf damage caused by pests and pathogens. Because the tubers of many varieties keep well in the ground for a year or more, it is a primary famine reserve crop in Africa.

The postharvest processing of cassava tubers is labor-intensive, and offers scope for productive research. Indeed, processing labor requirements may equal or exceed those for all other preharvest production activities. With appropriate processing, cassava tubers have great potential as a source of cheap food for urban populations, or, if demand develops, as livestock feed.

IITA has a continental mandate for cassava in Africa, and it has been successful in developing improved varieties that are high yielding, resistant to two devastating African diseases, and suitable for many consumer requirements. Improved varieties are expanding rapidly in Nigeria and in other countries of Africa. In the strategy for cassava, priority is given to breeding for local adaptation to diverse environments and cropping systems, with increased emphasis on the humid forest zone.

The most spectacular success in cassava research, indeed in all of African agricultural research, however, came not from improved germplasm but from biological control of a major cassava pest, the cassava mealybug. The cassava mealybug had devastating impact upon cassava in Ghana. Although the mealybug could be controlled by toxic pesticides, that approach was both ecologically damaging and too expensive for smallholders. The project controlled the mealybug through the release of its natural enemies identified in Latin America, and it has been an outstanding success. A Winrock International evaluation team estimated the benefit to African farmers at roughly U.S. $3 billion, large enough to cover IITA's operating budget for over 100 years.

In a workshop devoted to agricultural extension, it is necessary to note that this is one of the few examples where success is not dependent upon strong extension services. We are able to raise the natural enemies of the mealybug on

research stations and release them by aircraft or by persons on the ground. Villagers stepback from hunger, not even understanding why the destructive mealybugs have disappeared. This project demonstrates what biological control can accomplish by working with nature to benefit the resource-poor farmers of Africa.

Cassava processing is another focus of IITA research. Traditional processing and utilization involves onerous work, the burden of which falls primarily on women. 84 women-hours of labor are required to process 10 tons, the output of perhaps one hectare's production of cassava. IITA has adopted a food systems approach to postharvest research on cassava. There is great potential to save labor and improve quality. Preliminary results of this research were reviewed by Secretary Obimpeh during his visit to IITA last year, and they have been demonstrated in Ghana at the Accra Trade Fair.

IITA has a cassava scientist working with the Ghana National Root and Tuber Crops Improvement Project, associated with the Crop Research Institute in Kumasi. Starting with improved cassava materials from IITA, they are conducting adaptive trials in Ghana. Yields this year from 7 locations average about 25 tons per hectare without fertilizer, compared to the yield of local varieties of about 14 tons and a national average of 5 tons.

If Ghana is to realize its target of a 100% increase in yield by 1995, rapid multiplication of the best planting material must be a high priority. In traditional multiplication methods, cuttings from 1 ha can establish only 5 hectares of newly planted cassava. This severely restricts dissemination of new varieties. New multiplication systems have now been developed which increase the coverage by fiftyfold. Most maize farmers in the forest and transition zones intercrop with cassava. Global 2000, therefore, would be an excellent mechanism for launshing an effort to promote improved cassava, and we would be pleased to cooperate in incorporating cassava into the maize-based systems that are the central component of the project in Ghana.

If cassava yields do double over next five years, as we believe they can, there would be an imbalance between supply and demand. Cassava in Ghana today is consumed in traditional food crops. The surplus over consumption needs will have to be absorbed in exports or non traditional forms, such as animal feed and industrial products. Research today must be launched on utilization to avoid the logjam that might discourage production in the future.

I will conclude with the story of a Ghanian farmer with whom we collaborate. The farmer started to collaborate with IITA in 1985 after attending a training program at IITA in seed yam multiplication. The farmer started with 10 acres of seed yams, and the enterprise has grown to an annual production of 5 million seed yams which are distributed by the Ghana government. The farmer, who received a national award as the "Most Scientific Farmer in Ghana" a few years ago is Gloria Dua. She has been invited to share her experiences with participants in subsequent IITA training courses and in conferences in Nigeria. She demonstrates what is possible because of the availability of improved technology and the hardwork and enterprise of a farmer.

Status of Sorghum Research and Technology Development in sub-Saharan Africa

*Leslie D. Swindale**

I am responding to the request to supply information about the status of research and technology development in sub-Saharan Africa for sorghum, that is, crop improvement and the related crop management in the countries in which Global 2000 is working at the present time.

Zambia

First let me start at the bottom of the Continent. Zambia has a good research program on sorghum and I know that Global 2000 is in close touch with that national program, partly because of previous relations between the individuals. Dr. Jain, the country director of Global 2000 in Zambia was previously an ICRISAT scientist, and so were the current leaders of the national sorghum improvement and pearl millet improvement programs. One of the maize agronomists and several other scientists working in Zambia are also ex-ICRISAT scientists.

There are several released varieties of sorghum and pearl millet that are well adapted to the regions in which Global 2000 is working in Zambia. Furthermore, there is promise, soon, of a suitable sorghum hybrid that will be higher yielding than the available varieties and more attractive to the seed production companies in that country.

Tanzania

Tanzania is a new Global 2000 country, so let me dwell a little more on the importance of sorghum to that country. Nearly 20 percent of all the crop land in the country is devoted to sorghum. It is the second most important cereal crop grown on about half the area of maize, and the average yield is just under 1 t/ha, which is the highest of all the SADCC countries. Tanzania has an effective national research program on sorghum, and the resources and results of that program are available to help the Global 2000 program.

Several sorghum varieties were released some years ago by the EAAFRO organization but most of them are not grown by farmers. Sorghum varieties like Serena, Lulu D were not accepted by the farmers because of poor grain quality-- exactly the point that Dr. Marino was making yesterday-- but in more recent years, as Asst. Commissioner Moyo mentioned, a very good variety Tegameo, was released by the government. It has good grain characteristics and is liked by both producers and consumers.

So I would suggest that Tegameo is a good variety available to start the sorghum work of the Sasakawa Global 2000 project in Tanzania this coming cropping season. Seed is available in reasonable quantities

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and the necessary agronomic information has been developed by the Commission on Research and Training with additional information available from the university as well.

There is, therefore, sufficient technology to start the sorghum program in Tanzania. I hope that after one season Global 2000 will provide feedback to the researchers on how their package performs on the farm so that they will be assisted to produce more and better varieties for the future.

To my knowledge, at the present time, there are five other varieties that can be considered for use in on-farm trials in the different agroclimatic regions of the country. One of them--a variety developed at ICRISAT Center--is called SV1 (ICS V 112) in Zimbabwe where it has already been released for use. It is also being considered for release in several other southern and eastern African countries. So here we seem to have a variety which has substantial plasticity across different agroecological zones of the region.

Sudan

Rainfed sorghum occupies an area of more than 4,269,000 ha with an average yield of 550 kg/ha; irrigated sorghum occupies only about 365,000 ha with an average yield of about 1,300 kg/ha.

The rainfall in the rainfed sorghum areas ranges from 450 mm to about 750 mm. Two kinds of farms are available: (1) the large scale mechanized farms, where land preparation and sowing are done using mechanical equipment but all other activities are done manually and (2) the small farm where traditional manual production practices are followed. Yields are low because of several factors: low yield potential of varieties, poor soil fertility, shorter fallow period, soil erosion, and *Striga* infestation.

Despite the availability of water, the irrigated sorghums have low yield due to several factors: low yield potential of local varieties, delayed sowing because of labor competition, poor fertility, poor weeding, untimely irrigation owing to competition with cotton and groundnut, and pest infestation (armyworm, aphids, and stem borers) for late sown crops.

Adaptive Research--The Global 2000 scheme using the following improved package of practices in farmer managed irrigated trials has demonstrated 159 percent yield advantage over the average yield in the Gezira scheme project (2,774 vs. 1,071 kg/ha).

Improved package:

- -- High yielding hybrid Hageen Durra 1
- -- Seed rate 7 kg/ha
- -- Population density 160,000 plants/ha
- -- Fertilizer N 88 kg/ha; P 44 kg/ha

Three-to-fourfold yield advantages have also been demonstrated in the restricted irrigated plots (post floral irrigation) as compared to rainfed plots in the Blue and White Nile Corporation (1,709 vs 594, 2,610 vs 607 kg/ha). Greater emphasis on rainfed sorghum demonstrations is

required because 85 percent of sorghum in Sudan is grown in rainfed conditions.

New Promising Cultivars--A number of new promising sorghum cultivars/hybrids supplied from ICRISAT Center have shown promise under irrigation in preliminary tests at the research station at Wad Medani. Their yield performance have been significantly superior than the local improved cultivar, Dabar 1-1, and improved hybrid, Hageen Durra 1 **(Table 1).**

The fact that the new cultivars that I have mentioned have been introduced from overseas suggests that the national research program on the main staple cereal crop, sorghum, needs strengthening and support. An adaptive research and demonstration program like Global 2000 cannot continue to succeed if it is not backed up by adequate research.

In September, I will discuss with the Sudanese authorities and UNDP the possibility of ICRISAT returning to the Sudan to pick up where we left off with Hageen Durra-1. I hope that suitable arrangements can be made so that we will once again be able to contribute to sorghum and millet improvement in that country.

Ghana

There are a lot of people in this room who know much more about sorghum improvement in Ghana than I do. So I will tread warily in my remarks about the country.

The sorghum and pearl millet growing areas in Ghana fall within the northern Guinea zone in the Northern and Upper Regions of the country. They offer tremendous opportunities for food production improvement. The rainfall period in the Northern Region extends from April through October with an average precipitation of 1,000-1,400 mm; in the Upper Region it occurs during April-September with an average of 950-1,100 mm. The major cereal crop in the Northern Region is maize and in the Upper Region pearl millet. Sorghum occupies an important area (250,000 ha) in the two regions.

Table 1. Grain yield superiority of new sorghum varieties and hybrids over control variety and hybrid, irrigated trial, Wad Medani, 1987.

Variety/Hybrid	ICSV 112	ICSV 225	ICSV 214	CSH 6	CSH 11 (ICSH 153)	CSH 9
Yield advantage over Dabbar 1-1 (%)	160	163	166	181	190	208
Variety/Hybrid	**ICSV 361**	**ICSV 112**	**CSH 11**	**ICSH 109**		
Yield advantage over Hageen Durra 1 (%)	131	139	135	148		

Traditionally, sorghum is grown in mixtures with cereals (maize in the Northern Region and millets in the Upper Region) and legumes (cowpea and peanuts). Sorghum and millet yields are low (500 - 1,000 kg/ha) due largely to poor soil fertility, low plant density, low yield potential of local varieties, poor harvest index, low amount of rains, reduced rainfall duration (in recent years), and infestation diseases and pests the most important of which are grain mold and *Striga*.

National sorghum breeding research is carried out at Nyankpala Agricutlural Research Station (9° N latitude, 180 m altitude) which has an avreage rainfall of 1,050 mm.

To meet the requirements of farmers two types of sorghum cultivars are being sought. Firstly, sorghum varieties are needed that can be planted in the beginning in June and harvested during the end of October. These should be short in plant height and possess moderate levels of resistance to midge, grain mold and *Striga*. Secondly, sorghum varieties and hybrids are needed that can be planted at the end of July and harvested during the last week of October. They can be relay planted into early planted maize, pearl millet, groundnut, and cowpea. They should possess resistances to grain mold, midge, head bugs, and *Striga*. Shootfly and stem borer can also reduce yields in some years and cropping systems.

ICRISAT's West African sorghum improvement program has been cooperating with the Nyankpala research station especially in the area of screening of improved materials against these diseases and pests. As a result of this work the variety Framida was identified as a stable variety that is resistant to grain molds and Striga. This variety is being used by Global 2000 for on-farm trials. Its main disadvantages are realtively poor input response and red grain.

To help overcome these disadvantages we have supplied a white-seeded mutant of Framida to the Global 2000 program and to the Nyankpala research station. We hope it will prove useful in the farmers trials in 1990. At the same time the scientists at Nyankpala are working to increase the yield potential and grain quality of Framida while retaining its resistances to grain mold and *Striga*.

Some recent findings in the northern Guinean zone deserve consideration for further testing in Ghana. Intercropping of maize and pearl millet is traditionally practiced in southern Mali and in northern Ghana.

Because a farmer often has to optimize returns from a combination of crops, the overall productivity of the whole system is as important as the productivity of an individual crop. The land equivalent ratio (LER), which is defined as the realtive land area that would be required for sole crops to produce the yields achieved in intercropping, provides a measure of the relative advantage of intercropping. By this measure, the planting arrangement of 2 maize: 1 millet had 26 percent advantage over sole cropping, whereas a 1 maize: 1 millet arrangement had 12 percent advantage over sole cropping. The results **(Table 2)** confirm several years of previous experiments.

Furthermore, transplantation of the intercropped millet at the 3-4 leaf stage of maize was most advantageous **(Table 3)**.

New cultivars with higher yield potentials and improved pest and disease resistence are becoming available and they need to be tested in Ghana. For example, ICRISAT scientists have evaluated a number of promising sorghum varieties in collaboration with the national program of Burkina Faso in recent years. In the 1987 rainy season eight cultivars including a control local variety (Gnofing) were tried in multilocational adaptation trial, conducted at 10 villages in the 900-1200 mm rainfall zone. The cooperating farmers followed improved management practices (plowing and using N43:P40:K30 fertilizer). All the test cultivars gave significantly superior yields to the

Table 2. Maize and pearl millet yields, kg ha, at Sotuba and Longorola, 1987, in relation to planting arrangement

Arrangement	Sotuba Maize	Sotuba Millet	Sotuba LER	Longorola Maize	Longorola Millet	Longorola LER	Average LER
1 row maize : 1 row millet	2,900	460	1.14	3,280	345	1.11	1.12
2 row maize : 1 row millet	2,630	760	1.27	2,260	520	1.26	1.26

LER = Land equivalent ratio.

Table 3. Maize and pearl millet yields, kg/ha, at Sotuba and Longorola, 1987, in relation to the planting method of millet

Arrangement	Sotuba Maize	Sotuba Millet	Sotuba LER	Longorola Maize	Longorola Millet	Longorola LER	Average LER
Direct seeding of millet at 3-4 leaf stage of maize	2,650	530	1.19	3,250	460	1.21	1.20
Transplanting of millet at 3-4 leaf stage of maize*	2,390	830	1.24	3,130	555	1.25	1.24
Transplanting of millet at heading stage of maize	3,250	260	1.11	3,450	280	1.11	1.11

LER = Land equivalent ratio.

control local variety, Gnofing (**Table 4**); the superiority ranged from 143 to 207 percent. The cultivars, S34 and ICSV 111 IN, gave the highest yield of 2.43 t/ha as compared to the control. The variety S 34 has been consistently high yielding over several years and locations. It has been released in Cameroon and is in use by farmers.

Amongst newer cultivars the medium duration variety ICSV 1063 B has ranked first in trials in 1986-1988 in Mali and Burkina Faso. It resists lodging and shows resistance to the main leaf diseases of the region. The sorghum hybrid ICSH 507 ranked first and exhibited consistent performance across 12 sites in West Africa in 1988. It has proved superior in agronomic trials in 1989 at Bagauda. Nigeria, and is being considered for release in that country.

Conclusion

Improved sorghum and millet varieties are available to Global 2000 in all four countries in which it is operating currently. Tested input packages suited to the conditions of different regions of the countries are also available, particularly for rainfed conditions in which these crops are generally grown.

Even better varieties are becoming available may be tested in the Global 2000 program. Feedback to the scientists about their performance of these varieties on the farm will help guide scientists into more effective research in the future.

Intercropping improved maize and millet is proving successful in southern Mali and is spreading as an improved cropping system among farmers. It is likely to have application in Ghana where high yielding, mold and *Striga* resistant sorghum varieties are still not available at the farm level.

Table 4. Grain yield, t/ha, performance of elite sorghum cultivars in a multilocational adaptation trial conducted at 11 locations, Burkina Faso, rainy season, 1987

Improvement over control cultivar	Location										Mean	(%) control
	1	2	3	4	5	6	7	8	9	10		
S 34	2.67	2.40	2.26	2.17	2.78	1.96	1.84	3.32	2.83	2.09	2.43	207
ICSV 111 IN	1.71	2.79	2.69	2.08	3.30	1.53	-	3.07	-	2.28	2.43	207
ICSV 1049 BF	2.24	2.68	2.08	2.08	3.07	1.73	1.44	3.40	2.36	2.14	2.32	198
Gnofing (Control)	1.22	1.03	1.12	0.78	1.25	1.26	1.25	1.55	1.11	1.12	1.17	100

Workshop '89 Summary Report

*Christopher R. Dowswell**

Workshop 1989 "Feeding the Future: Agricultural Technology Development Strategies for Africa" was held in Accra, Ghana, on August 1-3, 1989. Approximately 180 participants were in attendance, including noted agricultural scientists, rural development and health care specialists, representatives of international donor and non-governmental organizations, and top policy makers from five African countries.

The Workshop was organized for two primary purposes: (1) to review the work and progress of four Global 2000 agricultural technology projects and (2) to discuss alternative strategies to strengthen agricultural technology delivery system to allow sustained growth in agricultural productivity, especially among small-scale, resource-poor food producers.

Three of the Global 2000 projects--in Ghana, Sudan, and Tanzania--are funded by the Sasakawa Africa Association (SAA) through a grant provided by the Japan Shipbuilding Industry Foundation (JSIF), whose Chairman is Ryoichi Sasakawa. A fourth project--in Zambia--is funded by the Bank of Credit and Commerce International (BCCI), whose President is Agha Hasan Abedi.

Workshop 1989 was the fourth in a series of consultations, sponsored by JSIF, and concerned with the alleviation of poverty and hunger and the improvement of health and nutrition in sub-Saharan Africa. Hosted by the Centre for Applied Studies in International Negotiations (CASIN), the 1989 Workshop was co-chaired by former U.S. President Jimmy Carter, Ryoichi Sasakawa, and Norman Borlaug.

On the first day of the Workshop, participants went to Ojobi village, Central Region, to help local farmers to harvest their SG 2000 one-acre maize production test plots and to attend an agricultural fair and meeting (Durbar) with tribal chiefs, regional government officials, and several thousands farmers. The remainder of the Workshop program was held at the Nkrumah State-House Convention Center in Accra. A synopsis of the major presentations follows.

Overview of the Global 2000 Projects

Nobel Peace Laureate, Dr. Norman Borlaug, leader of the Global 2000 agricultural program and President of the Sasakawa Africa Association (SAA), provided Workshop participants with and overview of Global 2000's agricultural projects. Borlaug began with a brief history of the genesis of the Global 2000 agricultural program. The initiative grew out of a query from Ryoichi Sasakawa, in the wake of the African famines of 1983-84, whether something could be done about solving the causes of stravation in

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Africa rather than just trying treat the symptoms through emergency food aid shipments. After consulting with agricultural scientists knowledgeable about sub-Saharan Africa, Borlaug told Sasakawa that sufficient technology was available to help small-scale farmers to double and triple yields bu that these technologies--some of which had been available for more than a decade--were not reaching millions of small-scale resource-poor producers because the "delivery systems" for these technologies were not functioning as the should and could be.

Sasakawa proposed funding several pilot projects in Africa to transfer improved food crops production technology to small-scale producers. About the same time, former U.S. President Jimmy Carter, also deeply concerned about Africa's food plight and looking for ways to help solve it, offered his collaboration and assistance. President Carter proposed the establishment of a non-profit organization dedicated to action-oriented projects in agricultural development and improved primary health care, which was christened "**Global 2000**" and headquartered at the Carter Presidential Center in Atlanta Global 2000 projects were conceived as fixed-term initiatives, conducted in collaboration with Ministries of Agricultural and various other governmental and non-governmental organizations.

The projects were designed to play a catalytic role in increasing the productivity of resources devoted to food crop production, with the idea that the Global 2000 staff would "work themselves out of a job" as national organizations integrated project principles and activities into their own programs and institutional structures. Borlaug based the Global 2000 agricultural program strategy on overcoming three critical bottlenecks holding back progress in food crop production.

First, national agricultural extension services had to be made more effective and dynamic as technology transfer organizations. To accomplish this, Borlaug proposed mounting large-scale field demonstration programs in one or two key food crops that were deficit in supply. Starting cautiously until the new technologies were validated, the field programs were then to expand rapidly until they involved tens of thousands of small-scale producers.

The second program objective, more difficult to achieve than the first, was to assist national government officials to develop new agricultural policies and investment plans to make agricultural technology delivery systems operate more effectively, especially in supplying improved seed, fertilizers, and credit to small-scale producers.

The third objective was to help strengthen food marketing systems through increased storage capacity and price guarantee and crop diversification programs to ensure food supplies more in balance with demand.

Borlaug reported at the Workshop that the field testing programs in Ghana, Sudan, Zambia had clearly demonstrated that markedly improved technologies are available for most of the major food crops, especially when grown under adequate moisture. Some 150,000 small-scale producers in these three countries have tested the Global

2000 recommended crop production packages and have overwhelmingly expressed their desire to adopt the new technologies, providing the necessary inputs were available and adequate economic incentives existed to use them. With success in the field testing programs and their institutionalization within national extension services, Borlaug said that the program emphasis is now shifting towards helping national governments to modernize their food technology delivery and marketing systems.

The Sasakawa-Global 2000 Project in Ghana

Several reasons explain the success of the SG 2000 Project in Ghana. A necessary condition, of course, was the availability of improved technologies. Ghana's Crops Research Institute (CRI), in collaboration with several international crops research institutes (CIMMYT, IITA, ICRISAT), had developed good technological packages for maize and, to a lesser extent, for sorghum. These highly profitable tehcnologies were capable of doubling and tripling yields within acceptable levels of risk for the small-sclae farmer.

Second, Ghana's government leaders viewed the SG 2000 project as highly complementary to its own agricultural development priorities and enthusiastically supported its from the outset. The Secretary of Agriculture and his deputies have played a major role in planning and coordinating project activities and several thousand Ghanaian extension workers have been responsible for taking these improved production technology packages to the country's farmers. Strong support has also been given by the Head of State and other top government leaders.

Third, Ghana's farmers have been eager and full participants in the field testing program. In 1989, more than 80,000 small-scale farmers are directly involved in the production test plot program. The Project's policy of supplying participating farmers with recommended inputs has been especially important factor explaining the rapid expansion in farmer participation.

New food crops technologies are now being added to the field program. Farmers are being introduced to new crops (soybeans), new cropping patterns (cowpea-sorghum crop relay sequence and improved cassava-maize inter-cropping) and the cost advantages of using higher-analysis fertilizer formulas (urea, diammonium phosphate).

Project staff will also launch a major demonstration and credit program in 1990 to assist small-scale farmers to build low-cost and functional on-farm grain drying and storage structures for resource poor farmers. SG 2000 also hopes to play an active role in helping Ghana to establish a more effective national seed industry.

The Sasakawa-Global 2000 Project in Sudan

The SG 2000 Project in Sudan began in 1986 with an initial focus on improving sorghum, millet, and wheat production. After the 1987-88 crop year, the SG 2000 staff discontinued their work on millet improvement because two years of

testing produced no suitable technology to extend to farmers. Project staff now concentrate their efforts on wheat and sorghum improvement in the irrigated areas adjacent to the White and Blue Nile rivers, which include one million hectares that currently are being utilized far below their production potential.

The wheat and irrigated sorghum technologies being demonstrated in the SG 2000 field testing program were developed by Sudan's AGriucltural Research Corporation (ARC), in collaboration with several international crops research centers (CIMMYT, ICARDA, ICRISAT). ARC's high-yielding wheat variety, Debeira, and its sorghum hybrid, Hageen-Dura 1, have been central to the SG 2000 technological packages. Other production recommendations include moderate use of the right fertilizer nutrients, improved crop husbandry practices, especially seedbed preparation, planting designs and densities, and improved water management.

Over the past four years, more than 3,000 wheat and sorghum farmers have participated in the SG 2000 field testing program. These farmers are enthusiastic supporters of the project recommendations. Average of 3 to 4 t/ha have been obtained during the past three years of field demonstrations, compared to current national averages of 1 to 1.5 t/ha for irrigated wheat and sorghum production.

Sudan currently has a 600,000 ton wheat deficit which is projected to exceed one million tons by 1992. This growing and unnecessary dependence on imported wheat has aroused growing concern among national leaders. A Technical Committee for Wheat Self-Sufficiency was formed in late 1988 by the Council of State to devise a plan to achieve self-sufficiency in wheat and bread production within five years. The Committee has presented a comprehensive list of resource requirements to meet these production targets. The plan calls for an increase in national wheat production from 200,000 tons to 1 million tons through doubling national yields and total area. In addition, production of 250,000 tons of the sorghum hybrid, Hageen Durra-1, will be promoted, since this hybrid produces an excellent flour suitable for mixing in proportions up to 25% with wheat flour for bread making.

To make the national wheat self-sufficiency a reality, the Sudanese government must follow through on several critical factors. Seed production of the best high-yielding wheat varieties (and the Hageen Durra-1 sorghum hybrid) must be rapidly increased. The right kinds of nitrogen and phosphorus fertilizers must be imported and supplied to farmers on time for optimum use. Water canals and courses in irrigated areas are also in sad repair and in urgent need rehabilitation, not only for wheat but also for the other crops grown in these favored agricultural areas.

The Sasakawa- Global 2000 Project in Tanzania

The SG 2000 Project in Tanzania was established in raly 1989, with a initial focus on improving maize and sorghum production among small-scale producers. Maize, the nation's primary food grain, will receive the major attention. Three main operational zones have been identified, in consultation with

government officials: (1) the northern highlands, focusing on the Arusha region (maize), (2) the central plateau, focusing on the Dodoma region (sorghum and maize), and (3) the southern highlands (maize), where the target region is yet to be determined.

SG 2000 participating farmers will receive technical advice as well as necessary inputs on credit. The recommended tehcnologies are based on research products and information provided by the Tanzania agricultural research service, as well as from CIMMYT, ICRISAT, and IITA. SG 2000 production recommendations include the use of improved varieties nad hybrids, moderate amounts of fertilizer, and improved cultural practices, especially planting densities and designs.

An extensive field demonstration and training program is planned for the first phase of the project. Although some preliminary trials were conducted during the minor season in 1989 (March-June), the first real cycle of the field testing program will begin in 1989-90 in October, the start of the main maize-growing season. By the third year, field program should involved tens of thousands of small-scale food producers.

The second phase is to move farmers into commercial production channels in which they secure their own inputs and credit. SG 2000 will seek to be a catalyst in assisting the government of Tanzania to develop a technology delivery system capable of serving small-scale farmers. This phase should become the dominant activity by year three or four of the Project.

The BCCI-Global 2000 Project in Zambia

The Zambia Agriucltural Project was launched in late 1986, with an initial focus on helping small-scale farmers to improve maize and sorghum productivity. Maize improvement is the major program thrust although expanded sorghum production is also being promoted in several lowe-rainfall areas.

Zambia's food production sector is comprised of a relatively few large-scale private farms (mostly established during the colonial period) and many small-scale, near-subsistence farmers who cultivate tribal lands. The larger-scale farmers use hybrid seed, fertilizers, farm machinery, and agricultural credit; these farmers produce large surpluses for commercial sale. Excellent maize varieties and hybrids have been developed and/or released in Zambia. Zamseed, the national seed corporation, produces enough hybrid maize seed to plant over 50 percent of the total national maize area. Small-scale producers, on the other hand, still remain outside the modern agricultural economy; they purchase few inputs, lack access to animal or machine traction, and produce little surplus grain for sale in the marketplace.

Over the past three years, Global 2000 staff and extension officers have worked with more than 3,000 farmers to grow individual production test plots to evaluate the Project's recommended technologies. The average yield obtained in these field plots has been about 4.5 t/ha, twice the national average. Another important Project achievement has been its success in getting more private and public banks involved in

granting production credit to small-scale producers. Increasing numbers of small-scale farmers are receiving production credit from various types of lending institutions, with technical backstopping provided by national extension agents.

During 1990, the Project staff plan to promote the use of oxen as a means to overcome current labor bottlenecks during land preparation and weeding. Global 2000 staff and extension officers will also work to improve and consolidate the newly introduced loan scheme. Efforts to influence policy to provide the economic incentives needed to enocurage farmers to adopt more productive maize technologies will also continue.

What's in the Food Crop Research Pipeline for Africa

Directors from three international crops research institutes and from Ghana's Crops Research Institute (CRI) made presentations to the Workshop on the status of food crops research and technology development.

Dr. Ronald Cantrell, Director of the International Maize and Wheat Improvement Center (CIMMYT), headquartered in Mexico but with many staff assigned to Africa, discussed maize imrpovement research. Cantrell first reported on CIMMYT's participation in the Ghana Grains Development Project during the past decade, which is funded by the government of Ghana and the Canadian Agency for International Development (CIDA) and has financed the stationing of CIMMYT and IITA maize and cowpea scientists, respectively, at the Crops Research Institute. Through this research collaboration, six improved maize varieties have been developed and released and new production technologies have been developed, tested by farmers, and accepted for adoption.

Cantrell reviewed the status of maize breeding for the major ecologies in sub-Saharan Africa. The largest category of improved maize seed (germplasm) available for tropical Africa consists of broadly adapted open-pollinated materials with resistance to major diseases such as maize streak virus, and mostly developed from experimental varieties provided to national programs by CIMMYT or IITA. Some outstanding lowland tropical quality protein maize (QPM) varieties with maize streak virus resistance are also available. These QPM materials offer a nutritional advantage over normal maize because they have 50% higher values of two essential amino acids, lysine and tryptophan, which are needed by human (and monogastric animals) to build proteins.

High-yielding maize hybrids are also increasingly available for tropical conditions. IITA has been a leader in this work since the late 1970s; more recently, CIMMYT has also launched a hybrid development program. Hybrids are already widely grown in Kenya, Zambia, and Zimbabwe. In most other Africa countries, however, national seed industries will have to be substantially strengthened before hybrids can be supplied to farmers.

A new generation of improved maize germplasm is becoming available that has resistance to various corn borer insect species, enhanced tolerance to drought and/or

aluminum toxicity in soils, and resistance to the parasitic weed, **Striga.** These new maize materials will reduce insect pest damage without having to use pesticides and will make maize cultivation more productive and less risky for farmers in some of Africa's more marginal production environments.

In another 10-15 years, Cantrell also hopes to see another whole new generation of maize materials developed through biotechnology (genetic engineering) research. DNA probes make it possible to identify, map, and select genetic regions in maize than control important qualitative traits, like insect resistance and drought tolerance. With genetic marking, selection for these traits can be done more rapidly and efficiently. Another exciting discovery, developed by a private U.S. company, has been a bacterial gene responsible for producing a substance that kills European corn borers which can be transferred into a micro-organism that occurs naturally in maize plants.

Dr. Laurence Stifel, Director General of the International Institute of Tropical Agriculture (IITA), headquartered in Nigeria, focused on research progress on cassava and cowpeas. He noted that IITAQ also conducts research programs on maize, yams, soybeans, and plantains. He clarified IITA and CIMMYT's policies concerning maize improvement research in Africa. By mutual agreement, CIMMYT takes leadership in supporting national maize research in Eastern and Southern Africa and IITA operates similarly in West and Central Africa.

West Africa is the Center of origin and genetic diversity of cowpeas, as well as the world center of production. IITA holds the world collection of cowpea germplasm and has been involved with national programs in long-standing cowpea improvement programs. IITA's cowpea research focuses on developing genetic resistance/ tolerance to important pests and diseases. IITA has succeeded in developing some new early-maturing varieties with resistance to several important insect pests, and with a diversity of seed color and plant type to meet consumer requirements. Four new cowpea varieties have been released by CRI and some 30 tons of seed has been produced for sale to farmers. Stifel believed that these improved cowpea varieties merited active promotion by the extension service and suggested that a cowpea demonstration component be added to the SG 2000 field testing program in 1990.

The second commodity discussed by Stifel was cassava, which is the chief source of food energy for the majority of people living in the lowland humid tropics and much of the subhumid tropics of West and Central Africa. He predicted that the importance of cassava is likely to grow substantially in Africa in future years. IITA has been successful in developing improved cassava varieties that are high yielding, resistant to devastating African diseases, and suitable for many consumer requirements. The most spectacular success in cassava reseach, however, has come from biological control of a major cassava pest, the cassava, mealybug, through the release of its natural enemies. With this devastating pest

under control, cassava has become the major source of increased food production in Ghana and other African countries during the past few years. The Ghana National Agricultural Plan targets a doubling of the average cassava yield over the next five years--from an average of 5 tons to 10 tons per hectare. To achieve such yield increases, however, Stifel said that new multiplication methods would be needed to speed up the diffusion of the best cassava planting materials.

Dr. Leslie Swindale, Director General of the International Crops Research center for the Semi-Arid Tropics (ICRISAT), headquartered in India but with a major satellite research center in Niger, discussed research progress in sorghum and millet. Close collaborative research ties exist between ICRISAT and several sorghum and millet national research programs, esoecially those of Zambia, Tanzania, and Sudan, where new high-yielding varieties and hybrids had been jointly developed and released for farmer use. ICRISAT has less research collaboration with Ghana, whose sorghum and millet improvement research Swindale believes in under-funded.

It has been difficult to develop improved varieties for Ghana with the required characteristics for maximum farmer acceptance. Head mold cause by several fungi has been especially serious problem for breeders to overcome in areas with relatively high moisture and rainfall in the latter stages of the crop cycle. The best improved commercial variety in Ghana continues to be Framida, and old variety originally from South Africa which is not particularly high-yielding, but which does have reasonably good resistance to head mold and to the parasitic weed, *Striga*. Unfortunately, Framida also has red seed containing tannins, which makes it less a preferable grain for consumers. A white grain version of Framida is being improved for yield potential and disease resistance.

Swindale underscored the problem of inadequate seed production in Africa, even in countries where superior sorghum and hybrids have been developed.
Swindale suggested that a mixed public-private seed sector may be needed to serve the seed needs of resource-poor and commercial sorghum farmers.

Mr. Emmanuel Addison, Director of Ghana's Crops Research Institute (CRI), provided an overview of his institute's food crops research and technology generation programs. CRI is responsible for developing improved food crop technologies for Ghana's farmers, especially the small-scale producer. Addison described cooperative programs with CIMMYT (maize) and IITA(crowpeas) under the Ghana Grains Development Project, with the West German development agency, GTZ, and ICRISAT in sorghum and millet improvement, and with IITA in cassava, yams, maize,plantain,soybean,and rice research.

Addison reported that CRI's greatest research successes have been maize breeding where a continuing stream of improved varieites have been released for use by farmers. No improved cassava materials have been released by CRI although the biological control program for the mealybug has had a major impact on improving national yields and production. Only one improved

sorghum variety, Naga white, has been released by CRI, but this variety has never been extensively grown by farmers. CRI does little research on pearl millet and no improved varieites have been released, even though more than 100,000 ha are planted to this crop.

Seed Industry Development Strategies for Africa

The session of seed industry development was led by Mr.Johnson Douglas, an international seed expert with 30 years of experience in the Third World. Douglas reported that, with the exception of Kenya, Zambia, and Zimbabwe, Sub-Saharan African countries have the least developed seed industries in all the world. In maize, for example, less than 30 percent of the total maize area is planted to commercial varieties and hybrids, despite the availability of many outstanding materials.

Successful seed industries, Douglas contended, develop when governments recognize the importance of seed in agricultural development and act upon that decision. Seed industries require the active cooperation of organizations involved in crop research, commercial seed production and distribution,seed quality assurance and control, agricultural extension, and agricultural credit. Because seed industries involve so many different groups that need to work toward common goals, a mechanism required to provide a forum to assist in the decision making process. Such a aforum--often called a National Seed Council (NSC)--must include representation from all key public and private organizations with an interest in the seed industry.

A dynamic seed sector can only develop when suitable improved varieties and hybrids are available and when new materials are continually streaming from the crops research programs. Since most food crops research in sub-Saharan Africa is done by public research organizations, policies are needed on (1) the release of improved varieties and hybrids for private seed production, (2) the seed quality control process, and (3) long-term strategies for cooperation between public and private research and seed production organizations.

Foundation seed is the bridge between the research program and that portion of the seed sector that multiplies and suplies seed to farmers. Foundation seed is provided by the crop breeding institution and is derived from what is called "breeders'seed." Fron this seed, all subsequent generations of commercial seed are derived. The policy on supplying foundation seed has a significant influence on how the commercial seed industry develops and a clear and fair set of policies are needed to determine the allocation of foundation seed to seed-producing organizations.

Douglas reported that most African Countries have created publicly owned seed organizations that have been costly to operate, ineffective in building seed demand, while often holding a virtual monopoly over national seed industries.
New national seed strategies are increasingly calling for numerous seed organizations involving a mix of public and private capital and ownership, but operating under free enterprise principles.

For private sector seed organizations to survive they must be able to charge realistic seed prices to cover full costs of production. The large subsidies currently provided to most public seed production organizations must be removed if more private capital and entrepreneurial resources are to flow into national seed industries.

Fertilizer Industry Development Strategies for Africa

The session on fertilizer industry development strategies was led by Mr. Lewis B. Williams, East and West Africa Liason Scientist for the International Fertilizer Development center (IFDC), headquartered in Alabama. Lewis was accompanied by Dr. Paul. L. G. Vlek, Director of IFDC's Africa Center, located in Togo.

Williams began his presentation with an soil fertility assessment in Africa's food-producing areas. He reported that expanding populations have pushed agriculture onto more marginal lands and have shortened the traditional fallow periods, from 8 to 15 years to less than 5 years, resulting in drastically declining soil fertility and environmental damage. Any soil fertility management strategy in Africa not based on greater use of fertilizers, Williams contended, would result in massive food imports to avoid widespread starvation.

Sub-Saharan Africa has the lowest rate of fertilizer use in the developing world and currently only produces 20 percent of its fertilizer requirements, compared with a self-sufficiency rate of 75 percent for the developing world as a whole. Given the infancy of the fertilizer sector in most African countries, and the very large capital investments required to build fertilizer production facilities, Williams predicted that sub-Saharan Africa would remain a major fertilizer net importer for at least the next two decades. Even so, he believes that accelerated growth in fertilizer use by small-scale food producers would occur during the next several decades.

Williams then went on to describe a series of measures that importing nations could take to lower the cost of delivering fertilizer nutrients to the farmgate. These activities include:

1) Improvements in demand forecasting, procurement, and logistics can result in potential savings of US$60-160/ton.

2) Importation of bulk fertilizer products and local bagging offers additional savings of US$17-30/ton.

3) Improvements in physical distribution systems offer another US$30-40/ton in potential savings over current practices.

4) Once demand approaches 100,000 product tons, importation of bulk fertilizer products and raw materials with local blending and bagging can offer potential savings of US$30-60/ton (This option requires $10-20 million in capital investments).

Rural Savings and Credit Strategies for Africa

The Session on rural savings and credit strategies was led by Dr. Dale Adams, Professor of Agricultural Economics at Ohio State University.

Adams has been a major research leader rural credit systems in the developing world for more than 25 years.

Adams decribed a general history of failure in informal agricultural credit systems directed at small-scale producers, depite large amounts of international and national money poured into them over the past three decades. Various factors explain these failures. One major reason is because formal finance systems typically involve large loans and deposits, secure collateral, relatively long-term financial instruments, and legal backing. Formal finance is directed to the elite of the society, who are required to come to the financial institution to transact their business.

In clear contrast to the failures of formal agricultural credit systems are the successes of informal credit systems that have traditionally operated in rural areas. Such informal credit systems involve loans from family, money lenders, and storekeepers. Informal finance systems frequently involve small loans and deposits, commonly function without collateral, typically deal with short-term transactions, and often operate in the legal shadows. Many participants in the informal system are poor people, women, operators of small businesses, small farmers, and the landless--people who are often unable to obtain formal financial services. Transactions in the informal financial systems usually occur at the doorstep of clients, at their place of work, or in popular markets.

An important objective of the Global 2000 projects is to increase amount of credit given to small-scale farmers and some success has been achieves. Zambia and Ghana. In Zambia, several private and public sector banks are extending production credit (for inputs) to farmers associated with the Project's field demonstration program, through group lonas made to their cooperative unions. In Ghana, several banks are making production loans to finance input distribution to participating farmers in the field testing program. SG 2000 and Ministry of Agriculture have the responsibility for recovering input loans, and most farmers have repaid their loans at harvest with grain equivalents.

Adams doubted that the Global 2000 agricultural credit schemes in Ghana and Zambia are self-sustaining. He noted that participating farmers currently receiving inputs on credit enjoy a large subsidy since Global 2000 and Ministry of Agriculture extension staff are so involved in input distribution and loan collection, and yet the cost of their salaries are not reflected in the cost of the inputs and credit provided.

Adams warned the Workshop goup that it will be very difficult for formal financial institutions to make any profit on small production loans (US$40-50) to tens of thousands of small-scale farmers. The transaction costs in the formal banking system are just too high. Instead, Adams syggested that policy makers pay more attention to the operations of informal credit systems in rural areas to see whether these might be strengthened and extended in scope.

Agricultural Policy Formulation for Africa

The session of agricultural policy was led by Dr. G. Edward Schuh, a noted U.S. agricultural economist and national policy advisor, who currently is Dean of the Humphrey Institute of Public Affairs at the University of Minnesota. Schuh's presentation focused on the role of economic policy in transforming agriculture in food-deficit developing countries.

The first question Schuh addressed is why so many developing countries are food deficit, especially those that are well endowed with national resources and have a major portion of their population engaged in agriculture. The major explanations, he believes, are due to (1) significant under-investments in human capital to modernize agriuclture and (2) economic policies that discriminate severely against the agricultural sector. Under-investments in human capital occur in agricultural research and extension, in training and education of the agricultural labor forces, in basic health care services for their rural populations. Forms of policy discrimination include grossly overvalued currencies, large explicit export taxes, barriers against agricultural exposts, protection of manufacturing sectors which make input costs and other consumer goods higher than they would otherwise be, and public marketing authorities that buy cheap from farmers and sell dear abroad. With such a configuration of economic policies, Schuh, said, it is little wonder that private investment levels are so low and that farmers lack incentives to develop their resources and productivity.

In formulating agricultural policy, Schuh said that a broad perspective is needed which that recognizes the high degree of complementarity between science and technology policy and economic policy, and which uses a general equilibrium perspective that considers trade policies, monetary and fiscal policies, exchange rate policies, general credit policies, and labor market policies.

Schuh listed six policy imperatives for transforming agriculture into the engine of economic growth it can must become in sub-Saharan Africa.

1) Fix absolute and relative prices in the economy to reflect comparative advantage (actual and potential); don't discriminate against agriculture.

2) Make agricultural production more profitable, especially in commodities that can have a comparative advantage in international markets or a strong domestic demand.

3) Raise investments in the agricultural sector to socially optimal levels in agricultural research, education, and physical infrastructure.

4) Improve performance of domestic capital and credit markets through innovative systems capable of mobilizing rural savings, infusing funds into the rural sector, and distributing credit to resource-poor farmers.

5) Establish sound monetary policies that have neutral effects on the economy, bring stable prices, and promote fiscal responsibility in government.

6) Establish sound sectoral adjustment policies in agriculture, especially to assist in long-term adjustments for displaced labor, as agricultural and economic develops proceeds.

In his concluding comments, Schuh stressed the fact that sound national economic policy in today's world requires an international perspective. International capital and information flows have increased enormously and a global marketplace increasingly has become a reality. National policy makers in developing countries must learn to deal this change; there is little to be gained from wishing they could go back to an earlier day.

Ghana's Agricultural Development Strategies

Ghana's economic recovery program is cited by the World Bank and the International Monetary Fund (IMF) as a model for other Africa countries. Ghana's Secretary of Agriculture, Commodore Steve Obimpeh (Retd.), outlined the agricultural development portion of Ghana's Economic Recovery Program (ERP), which was launched in 1983 by the government of the Provisional National Defense Council (PNDC), with financial support from the World Bank and the IMF.

The ERP represents the first serious attempt in two decades to address the proper management of the Ghanaian economy. Previous government policies had resulted in a ever-worsening economic spiral which increased the incidence of poverty, negatively skewed income distribution, and adversely affected the agricultural sector. These misguided policies seriously damaged Ghana's agricultural economy, resulting in a steady decline in per capita food crop production spanning two decades.

Ghana's deteriorating food situation reached famine proportions in 1983 due to a severe drought, widespread bush fires, and the return of over 1 million Ghanaians from Nigeria. Since 1983, the government of the PNDC has taken a series of measures to get agriculture moving forward again. The PNDC has sought to develop a more coordinated and integrated development program aimed at renewed, vigorous and efficient growth in the nation's key economic sectors: agriculture, energy, industry, education, and health.

With World Bank funding, a US$53.5 million project was launched in 1986 to rehabilitate the agricultural sector. The medium-term agricultural development objectives are to motivate farmers, fishermen, and herdsmen, especially the small-scale producers, to increase their agricultural productivity so that they can become competitive on the world marketplace.

In the crop sub-sector, the strategy is to promote agricultural production through increased productivity on small-scale farms, reduce post harvest losses, reduce marketing and distribution costs, increase the industrial processing of horticultural and food crops, and expand the scope of non-traditional export crops. In the livestock sub-sector, the strategy is to increase private investments in the production of poultry, pigs, and small ruminant animals, and to develop both dairy and beef production through an effective program of disease control and improved husbandry practices. In

the fisheries sub-sector, the strategy is to encourage sustainable exploitation of the marine and fresh water fish and shell-fish and to encourage greater processing and marketing.

Despite the many policy reforms initiated under the ERP, Obimpeh reported that Ghanaian agriculture still faces formidable challenges to maintain momentum in the modernization of the sector, sue to the still relatively poor state of the economic, social, and administrative structure, and the depleted manpower base. Farmers still have limited access to credit, inputs, and efficient market systems. Further, the demand for Ghana's agricultural products in both domestic and foreign markets is still weak. These constraints are fast becoming major impediments to further growth and development in the agricultural sector.

P.V. Obeng, Chief Minister in the PNDC, told Workshop participants about additional steps being taken by the government to expand, strengthen and diversify Ghana's food-producing sector. Obeng made a special point of recognizing the agricultural development contributions to Ghana of many international agencies, including IFAD, CIDA, USAID, JICA, FAO, UNDP, and the World Bank. He said that it is the "sum total of these efforts that is leading Ghana to greater prosperity." With Ghana experiencing increased grain harvests and market surpluses, Obeng described policy efforts to expand the demand side to assure that farmers are not pushed into production and thus become vistims of their own hard work. He told of plans to expand the industrial food processing of maize and soghum as well as to use these grains as stocks for livestock and poultry feed rations. Farmers will also be encouraged to grow new food crops, such as soybeans, as well as export crops like tropical fruits.

Head of State J.J. Rawlings, in his special address to Workshop participants, called upon his own people and government officials to make the dream of a Green Revolution in Ghana a reality. Too often, Rawlings said, Africans have tended to blame former colonial powers and industrialized nations for all their economic woes. He urged his country men and women to intensify their efforts to transform Ghana's traditional agricultural systems so that the fruits of economic progress can benefit the nation's largest and most neglected labor force--its peasant farmers.

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