A Workshop Report

REGENERATIVE FARMING SYSTEMS

Washington, D.C.
December 10-11, 1985

RODALE INSTITUTE

Regenerative Agriculture Association

Rodale International

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INTRODUCTION

The future of agriculture exists as much in the questions yet to be asked as in the answers which are being found. Any workshop that is successful is at its best a mechanism for asking important questions and seeking to find answers. If for no other reason, that is why the "Regenerative Farming Systems Workshop" held in Washington, DC can be termed a success.

Participants in the workshop represented a broad range of interests. There were those who were aware of Rodale's approach to regenerative farming and there were those who were not. There were those already using regenerative technologies and there were those who were skeptical. Government agencies, universities and representatives of several international private voluntary organizations were represented. The diversity of the participants backgrounds and interests was a bonus resource.

What became clear during the course of the workshop was that many individuals and agencies, governmental and private, are testing and implementing regenerative farming technologies. As a result of this workshop what we have moved closer to is a new way of looking at things. We can see how a variety of regenerative technologies can link together in a symbiotic relationship, each reinforcing the regenerative capacity of the other.

This publication seeks to make available to the reader not only the individual papers that were presented during the workshop, but also the questions that were asked and some of the conclusions that were reached. For those that were not participants in the workshop, we hope that this publication will stimulate continuing discussion of the potential for regenerative farming systems.

Kenneth W. Tull
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INTERNAL RESOURCES AND EXTERNAL INPUTS:
THE TWO SOURCES OF ALL PRODUCTION NEEDS

Robert Rodale

INTERNAL RESOURCES AND EXTERNAL INPUTS --
THE TWO SOURCES OF ALL PRODUCTION NEEDS

Robert Rodale

Just before World War II, when I was 11 years old, my father bought a 63 acre Pennsylvania farm, which he managed as the research center for the farm and garden magazines that he published until his death. But he didn't actually work the farm himself. That job was given to me and to several very old hired men -- the only people he could hire during wartime. My chief instructor had actually met Abraham Lincoln. And he thought it important that I be taught the old ways of farming as well as what was then new, such as the use of tractors. My farm education therefore spanned the historic transformation of agriculture from largely hand and animal work to a modern industry.

My father shaped my agricultural education largely through reading and conversation. The first agricultural book he gave me to read was Farmers of Forty Centuries, by Franklin Hyde King. Then he introduced me to the writings and correspondence of Sir Albert Howard, the British plant breeder and agronomist who created what my father began to call the organic system of farming. Our dinner table, every evening, was a seminar on what is today called resource-efficient agriculture.

While still in college, I began editing our farm magazine and taking on some business responsibility in Rodale Press. That was in 1949. For the 36 years since then, I have worked continuously in both agriculture and as the manager of what has now become a rather large publishing business. My job has not always been easy. As any farmer knows, there are good years and not-so-good years. Many times I have worried about finances, and about being able to meet the payroll. And like most of us, I have also worried about the financial well-being of farmers.

During the past few years, though, I have tried to turn my normal inclination to be a worrier into more constructive thinking. Instead of thinking primarily about the end result of productive enterprise, I have tried to focus my thoughts on the beginning of the process.

What is feeding the roots of the production process, I asked myself? Where do the things come from that people use to produce food as well as all other things?

I especially thought about where the resources for agricultural production come from, because almost everywhere in the world today farmers are having great trouble producing food and fiber while still maintaining a healthy bottom line without government subsidy. Few farmers in this country seem able to do that, and the situation is not much better in other parts of the world.

Finally, part of the answer came to me. Farmers have two kinds of resources, I realized. One set is internal, meaning things that are present within every farm. And the other is external -- the things that are brought into the production system of some farms from outside. The chart on the next page illustrates this graphically.

The internal resources of agriculture -- as you can see -- are illustrated on the left side of the chart. And on the right are the external inputs that are often used in farming, especially in the highly developed countries. I should point out that on each side of the chart are illustrated not only the resources themselves, but also the mentality that accompanies the use of those resources.

The usefulness of this chart becomes more clear when you think about the history of agriculture. People have been farming for about 10,000 years. If we assume for the sake of this discussion that agriculture is exactly 10,000 years old, then for roughly 9,900 years farmers used only internal resources as the source of their production. There were no meaningful inputs from outside farms until about 100 years ago.

These internal resources are much less expensive than are external inputs. They are not exactly free, however. You have to either own or buy a farm to have the internal resources for agricultural production. But their cost is largely a once and done affair. As long as you can pay the taxes on your farm, internal resources are yours to use at no extra cost.

Let's discuss a few of the specific resources of the chart, starting with the soil.

On the left side I have simply written the word soil, because it is obvious to me that soil is the most important internal asset of farmers. Without soil, to my way of thinking, agriculture as we know it is not possible. What the stage is to a theater, what an office is to other forms of business, the soil is to farming.

The column on the right begins with the words hydroponic medium -- the place where a totally soilless kind of agriculture can be practiced. Hydroponics is an extremely high input way to grow food. In ordinary hydroponics, everything needed with the exception of sunlight must be supplied from outside. But there are also forms where even artificial light is used to substitute for sunlight.

And some people with whom I have talked actually believe that after all the soil is exhausted and eroded away, we will be able to grow our food hydroponically. The economics of food production do not at all favor hydroponics today, but the ultimate "high input mentality" is represented by that idea.

The next word on the chart is sun. In the days before the Industrial Revolution, agriculture was the primary power collection system of human communities. Sunlight was the source of that power. Agriculture's task was to collect those rays over the growing season and embody the energy they represented in seeds and other forms of food. Without that way of collecting, concentrating and storing energy, cities and many other human communities would not have been able to exist. Sunlight, therefore, has been a very important internal resource of agriculture.

RESOURCE SYSTEMS
FOR AGRICULTURAL PRODUCTION

INTERNAL	EXTERNAL
SOIL	HYDROPONIC MEDIUM
SUN - main source of energy	SUN - energy used as "catalyst" for conversion of fossil energy
WATER - mainly rain and small irrigation schemes.	WATER - increased use of large dams and centralized water distribution systems.
NITROGEN - collected from air and recycled	NITROGEN - primarily from synthetic fertilizer
MINERALS - released from soil reserves and recycled	MINERALS - mined, processed, and imported
WEED & PEST CONTROL - biological & mechanical	WEED & PEST CONTROL - with pesticides
ENERGY - some generated and collected on farm	ENERGY - dependence on fossil fuel
SEED - some produced on-farm	SEED - all purchased
MANAGEMENT DECISIONS - by farmer and community	MANAGEMENT DECISIONS - some provided by suppliers of inputs
ANIMALS - produced synergistically on farm	ANIMALS - feed lot production at separate location
CROPPING SYSTEM - rotations and diversity enhance value of all of above components	CROPPING SYSTEM - monocropping
VARIETIES OF PLANTS - thrive with lower moisture and fertility	VARIETIES OF PLANTS - need high input levels to thrive
LABOR - most work done by the family living on the farm	LABOR - most work done by hired labor
CAPITAL - initial source is family and community; any accummulation of wealth is reinvested locally	CAPITAL - initial source is external indebtedness or equity, and any accummulation flows mainly to outside investments

In more recent times, though, much of the energy going into food production comes not from the sun but from purchased supplies of fossil energy, in particular oil and gas. Far more energy units go into food production in an input intensive system than come out in food calories. So the sun therefore has become not the only source of energy but merely a catalyst needed for the conversion of fossil energy into food energy.

Time and space don't permit discussion of each item on the chart, but nitrogen is especially important. Protein production depends heavily on nitrogen. And around the world, nitrogen is the plant nutrient most often either lacking or limiting to increased production.

Yet we live in an atmosphere containing 78 per cent nitrogen. And there are several important ways that the abundant supply of nitrogen in the air can be captured and used by plants. Legumes do that effectively, in combination with special bacteria on their roots. And some microbes that live freely in the soil also can collect nitrogen from the air and make it available to plants.

Those nitrogen collecting systems -- as well as methods to recycle nitrogen within the farm -- can be extremely effective and low in cost. There are also ways to manufacture nitrogen synthetically and use it to substitute for the collection of nitrogen from the air. That approach to nitrogen supply is stated on the right side of the chart.

The Balance Between Inputs and Internal Resources

As I said earlier, until quite recently all farmers produced all their crops using only the resources on the left side of the chart. They paid for nothing except the farm itself. Nobody from outside sold them anything. Farming was an exercise in almost total self-reliance.

About a hundred years ago, several things happened. One was that the need for higher yields to feed the world's expanding population became obvious. Another was that scientists had learned enough about chemistry and biology to make improved fertilizers and pesticides. And finally, late in the last century industry began to develop the technology and the means to make and deliver large quantities of agricultural inputs.

The combination of those three events caused the most rapid and significant change in the structure of agriculture that the world had ever seen. Production increased dramatically wherever people were able to apply the high-input methods that had been developed. The transition to an industrialized type of agriculture was seen as a big success.

In recent years, though, some very serious questions have begun to be raised about high-input agriculture. Along with the increased production, we began to see destruction and economic imbalance as well. Soil erosion is now at its highest level in history. Overproduction of many crops is depressing prices, and forcing many farmers to leave the land and their chosen way of life. Governments are being burdened by the extremely high cost of subsidizing almost every facet of agriculture. For example, in the U.S. the transportation system used by farmers and farm input suppliers is subsidized heavily. So is the agricultural science and education system and the Soil Conservation Service. And government supports for farm commodity prices are so great that they have become an extremely significant part of the federal budget deficit.

Why are all these negative side-effects of high-input agriculture happening? Is it because of failure to fine-tune the production system properly? Or is there a more fundamental problem?

My answer is that the world's agricultural systems do indeed suffer from a fundamental problem. But it is a problem that can only be seen when you look at the whole sweep of agricultural history -- and when you view the resource systems of agriculture in the way I have presented them in the internal resources versus external inputs chart.

What has happened is that the rapid introduction of external inputs into agricultural production over the past century has unnecessarily diminished the strength, vitality and usefulness of the internal resources of farmers. In almost every case, inputs listed on the right side of the chart have invaded the territory of the paired internal resource on the left side and have rendered that resource less powerful. Inputs have been introduced into agricultural production in ways that have unnecessarily diminished the vitality of the historically-important internal resources that farmers have relied on for thousands of years.

And not only has each kind of input diminished the internal resource to its left, but the collection of external inputs has worked together in a way that has diminished the value of the collection of internal resources. That is mainly the result of what I call the high input mentality -- the belief that agriculture has become an industry like any other and should "grow up" and begin buying and paying for a much larger percentage of all its production needs.

The best way to use the chart to understand what has happened is to realize that the dividing line can be moved to either the left or the right by agricultural policy. For 9,900 years, the line was at the extreme right. There were no extgernal inputs, and internal resources formed the production foundation of all agriculture throughout the world.

Within the past century, the line has moved from right to left and now has "invaded" much of the territory of the internal resource portion of the chart. There has literally been an invasion of the internal resource potential of agriculture by the collection of inputs that have been invented, made and sold to farmers. Few people understand the fact that that invasion has happened, and fewer still realize that it can explain why industrialized agriculture is so uneconomical and requires such heavy subsidization to survive.

The goal of regenerative forms of agriculture in the developed countries is not to eliminate inputs, but to push the pendulum to the right. It should move far enough to the right to allow farmers to again run profitable businesses and also to regenerate the resource systems on which their long-term viability of their farms depends.

The goal of regenerative approaches to agriculture in less developed countries is to educate both farmers and farm policymakers to the tremendous importance of agriculture's internal resource systems. Good scientific efforts and sound educational efforts can cause the internal resource area to expand and become an even more solid foundation on which to base a productive agriculture.

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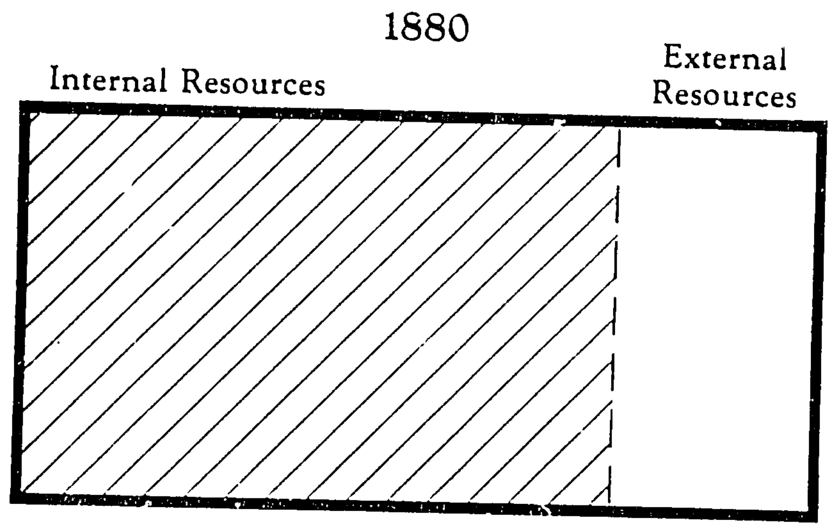

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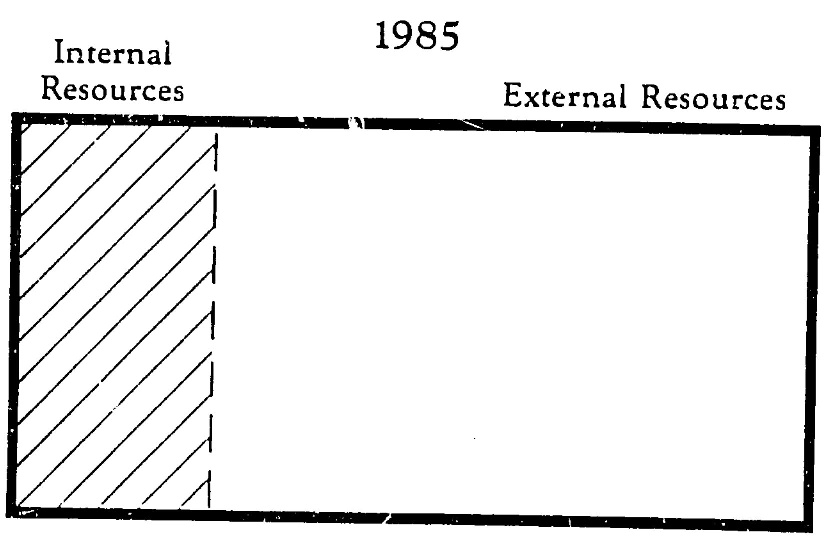

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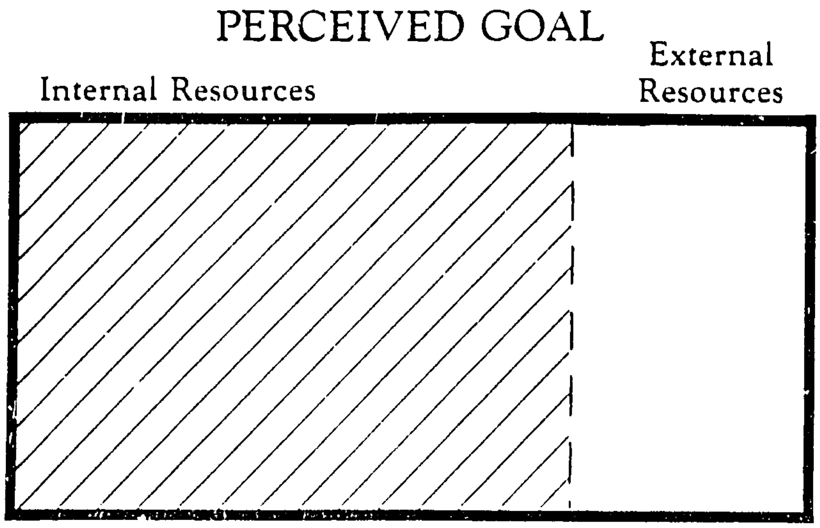

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Additional points covered in presentation
and not covered in original paper:

1) The line dividing "internal" vs. "external" resource use should be viewed as an approximation. There are large differences between farms.

2) The essences of the Rodale philosophy is to provide farmers with an independent source of information, one not linked to input suppliers.

Key discussions in depth:

Dover: I am Michael Dover, an independent consultant. I was wondering, Mr. Rodale, where you think the move toward biotechnology is going to be taking this whole system.

Rodale: I see biotechnology in one sense as better plant breeding or more effective plant breeding. I think it can be used very effectively to reduce input and a lot of the work that is talked about is in that area. There is another side of the coin though, a lot of the biotechnology work that is going on now is aimed at making it easier for more inputs to be used, particularly in weed control. One of the easiest tasks to be accomplished with biotechnology is to make crop plants more resistant to herbicides, therefore making farmers more dependent on herbicides. That is what we are faced with, it can go either way. That is why I think it is important to have some kind of overall framework to look at the bottom line not just in purely accounting terms, but in biological terms. This chart really is a kind of auditing system for farming that looks not just at the way scarce resources are used but also the way abundant resources are used.

Robins: You commented that you did not take any longer a purely organic gardening, if I can use that rather crude term, but recognizing the certain kinds of inputs are part of the game. Can you generalize on what kinds of inputs, water versus minerals versus pest control versus varieties that carry kinds of resistances? Can you generalize in terms of the kind of inputs that might work?

Rodale: There is a fundamental difference between the organic farming approach and the regenerative approach. The organic approach is like an all or nothing. It is like being pregnant or you are not pregnant. The farmer says I am going to adopt this whole system, which means basically no pesticides, no fertilizers and that is quite a big commitment for a farmer to make. It really gives a lot of people's credit that they did make that commitment and there are as many of them that still are. The organic system the way I interpret it fits within the regeneration concept but the regeneration concept goes further. But the fundamental difference with regeneration is that it offers for the farmer the potential to take steps into regenerative systems. Like we showed them that chart and we say there is the dotted line in the middle, imagine where it is in your situation and them move over a little bit from left to right step by step. We need at this point to step back and in effect reinvent food production in the way that marries the two goals of conservation and agriculture in a unified system that not only prevents erosion but actually builds the soil. In other words the fundamental idea of regenerative agriculture is to reinvent food production in a way that causes the resource base to get even better progressively over that causes the resource base to get even better progressively over time. And that is a very ambitious goal and we don't have all the information and the tools yet to do that. I think my hope, my dream is that regenerative agriculture will be based largely in perennial crops, not only trees and horticultural crops, but grain crops. That is why the perennial grains on that slide show are so important. The real regenerative system, especially on sloping soils used perennial crops for grain production.

Swanberg: I think the labor question is a really interesting one with this kind of regenerative agriculture. Your intercropping, relay cropping and from data from the Kenya area that I worked, you get a peak in labor demand at your seeding, first weeding and fertilization application such that it determines the amount of land that you plant per family. If you follow the right hand side, the external side and say alright, now double the use of fertilizer and maybe some pesticide, you would be demanding more labor at that peak period. Whereas if you go for more intercropping more relay cropping, and more legume rotations, pigeon peas in the off season that bridge the dry season from your short range to your long range, you're basically adding labor at the time when you don't have a peak in labor. So you can really increase your labor productivity without putting a strain on the peak labor demand period.

Wheeler: What you are trying to do as I understand it is to move into that system and make it more effective. I think that that is a very realistic way of going about it. If you are talking about rearranging almost the whole thing, then I think you are really up against the wall. In other words, the interventions have to be focused, carefully thought through-because farmers are reluctant to adopt them in the first place. If you make one mistake, you've made a very important mistake to that person or that family and they've learned that. I am just saying that I know that you are aware of all these things, but a management system, in my opinion in agriculture in terms of the farming system is much more complicated than anvthing we have in the U.S., and; therefore, when we intervene, we have to target it and be patient enough to move it step-wise.

Rodale: I have been talking to different people who are perhaps more experienced in specific agriculture farming in Africa than I am, and I asked them if farmers are resisting these packages because they don't have control, and I had an interesting talk with Steve Carr about that before, and he said that the farmers know within their own system, with a more indigenous system, they may get lower yields, but they know they can get some kind of crop every year. When you come to them with a package of inputs from outside, they know that they are going to get bigger yields for four years, but the fifth year, they may get no yield at all, and they may not want to tolerate that.

Kramer: I would agree wholeheartedly, Bob. I think that the key that we found in our agrohorticulture programs, which integrate trees and agriculture practices, is participation of the people receiving the assistance, and I particularly avoid the work, package, because it is really not a package at all, it's just that they are generating the types of interventions that they want to undertake. We may provide assistance in the form of creating a nursery, in the form of stimulating community groups gathering together to discuss common problems, and the form of guiding them towards certain practices that they may want to adopt. Ultimately, it is them who decide what they want to do, be it the agroforestry interventions that we are proposing.

Summary of Other Discussion:

Bertrand: Congratulations to Bob Rodale for the idea of regenerative agriculture. It gives us an acceptable tool to communicate on this subject.

Back to the biotechnology issue - commercial interests are currently in the making. The emphasis is more on external inputs but it doesn't have to be that way. Biotechnology could encourage crops that would be tolerant of drought, insects, etc.

Don't fall in the trap of thinking that soil has everything plants need. Many African soils are deficient in phosphorus.

Scarborough: Regenerative agriculture is labor and management intensive. What are the implications for government policy and training?

Mukusya: The current direction for agriculture is planting in rows, using specific measurements, and fertilizers.

We are looking at crops that can feed people and that don't require more money from the farmers pocket.

Labor -- we believe in communal work -- which works fine in the village. On large-scale farms, machines are used which is a different story.

Scarborough: Does the system require change?

Mukusya: Tr system is one that almost all the people know from the beginning.

Sands: The reorientation needs to be at the "expert level." The farmer understands the regeneration concept.

Carr: An adjustment is needed because more space isn't available. The urban population must be fed. Farmers need to adjust to these increasing demands, especially the population explosion.

Perennial grains need more space than do annuals but less land will be available. How will they work?

Prindle: Irrigation shouldn't be on the external side of Bob's diagram. In Somalia, irrigation is a big consideration. We need to determine how to irrigate in a renewable resource fashion.

Rodale: The chart is a general view. We, of course, need to be specific to each country and condition.

It is true that irrigation has been used for a long time and it is very valuable but internal resources should be looked at first. We need to look at irrigation in each specific situation..

Morgan: Regeneration is a system, an approach, a set of principles. The specifics must be handled individually.

Winter: What is the total production of regenerative farms? Africa has no margin for decreased yields.

Morgan: In our U.S. survey, we found that one-third of the farmers had a decrease in yield. It's essential to have a strategy. If a farmer plants corn year after year with no inputs, he'll have problems. However, if he plants corn with a small grain, again with no inputs, it's a different matter.

Bakker: Farmers will change but they need the tools to do it. Nomadic people are dying because they have lost their animals -- camels, donkeys, cows, sheep. They have nothing to extend themselves with. They need help in their transition to farming in the form of a long term commitment -- and not from "asphalt farmers."

RESOURCE EFFICIENT FARMING SYSTEMS AND TECHNOLOGIES

C. A. Francis, R.R. Harwood, W. C. Liebhardt,
C. R. Kauffman, and T. C. Barker

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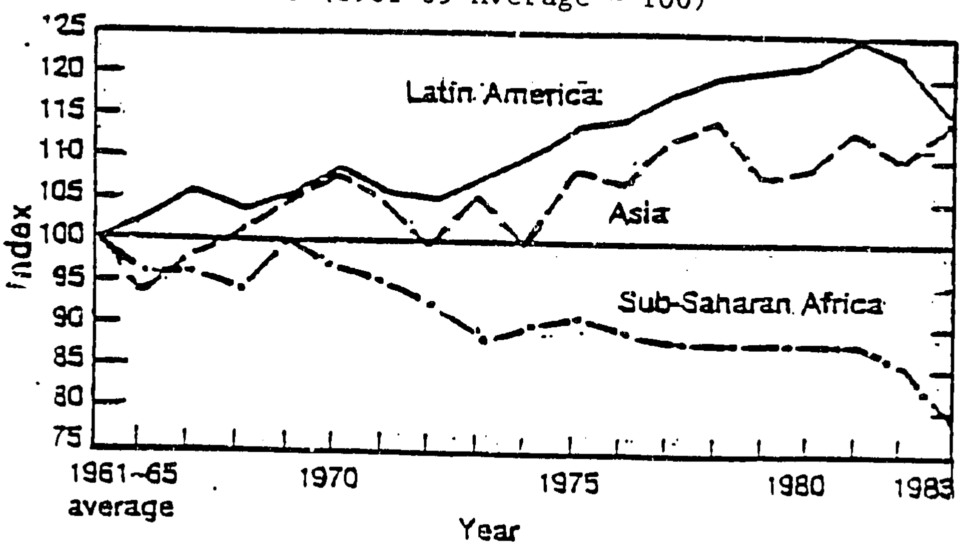
INTRODUCTION

Technology, Food Supply, and Rural Incomes in Africa

Improved agricultural technology has been slow to reach the majority of farmers in most countries in Africa, particularly the farmers with limited resources. There are many potential reasons why -- poor soil fertility, small farm size, traditional land tenure systems, lack of capital and other resources, low level of education. Perhaps the right alternative technologies have not been available. Most improved technology has been based on a substantial investment in external inputs rather than a rational assessment and logical development based on internal resources. The role of women in African agriculture has been grossly underestimated. The net result has been a stagnation of food production and agricultural development (Office of Technology Assessment, 1984).

Unique among regions of the developing world, Africa has experienced declining per capita food production during the past decade. Figure 1 (World Bank, 1984) shows the recent trends over two decades in three developing regions. Per capita food production has increased about 15 percent in both Latin America and Asia, while it has declined about 20 percent in Africa. Drought, political instability, emergence from colonial rule, lack of emphasis on development of the agricultural sector, and increasing population have all contributed to this trend. Whatever the specific causes, it is clear that the overall development strategy has been ineffective in meeting the challenges of food production to serve human needs in Africa.

Figure 1. Index of Per Capita Food Production, 1961-65 to 1983 (1961-65 Average = 100)



SOURCE: U.S. Department of Agriculture. In: World Bank, *Toward Sustained Development in Sub-Saharan Africa*, 1984.

When individual country statistics are considered, the situation is even more grim (Figure 2). During the decade from 1969-1971 to 1979-1981, total food imports have increased 134% (U.S. Congress, 1984). In Zambia, the increase has been more than 300 percent, in Nigeria and Mozambique more than 600 percent, and in Somalia food imports have increased by 1000 percent. More critical to the long-term welfare of countries in Africa, food production per capita has declined in 26 or 34 countries. The decline has been more than 10 percent in 15 countries, and more than 20 percent in six of these selected countries in the table. The decline in Somalia has been 35 percent. The list of statistics does not begin to describe the costs in human terms of this lack of food.

Figure 2. Food and Agriculture in Selected Countries (U.S. Congress, 1984)

	Volume of food imports (000 metric tons)		Food aid in cereals (000 metric tons)		Average index of food production per capita, 1979-81
	1974	1981	1970	1980	1969 – 1971 = 100
Angola	149	244	0	25	31
Benin	3	93	9	11	95
Burundi	7	19	6	12	100
Cameroon	31	106	4	9	101
CAR	7	14	1	3	102
Chad	50	14	13	14	106
Congo	34	58	2	2	32
Ethiopia	118	207	59	228	35
Ghana	177	255	43	94	74
Guinea	63	134	49	34	37
Ivory Coast	172	519	4	0	110
Kenya	15	534	2	173	35
Lesotho	49	95	14	44	36
Liberia	42	111	3	28	95
Madagascar	114	258	7	25	94
Malawi	17	113	—	17	95
Mali	281	102	114	50	38
Mauritania	113	182	48	108	77
Mozambique	52	368	34	155	73
Niger	155	89	75	11	73
Nigeria	389	2,441	7	0	91
Rwanda	3	16	19	15	104
Senegal	341	458	28	153	76
Sierra Leone	72	58	10	12	31
Somalia	42	432	110	330	65
South Africa	127	476	—	—	104
Sudan	125	305	30	195	102
Tanzania	431	285	148	237	91
Togo	6	62	0	4	90
Uganda	37	37	16	57	36
Upper Volta	99	71	0	51	94
Zaire	343	538	—	17	96
Zambia	93	295	1	64	92
Zimbabwe	56	21	—	18	92
Total	3,380	9,099 (+134%)	378	2,213 (+153%)	91[a]

[a]Average index, weighted by population.

SOURCE: World Bank, *World Development Report*, 1983. In: U.S. Congress, House Committee on Foreign Affairs, *Feeding the World's Population: Developments in the Decade Following the World Food Conference of 1974* (Washington, DC: U.S. Government Printing Office, 1984), p. 78.

Even in regions where food is available, static or declining income levels have made the basic elements for survival increasingly inaccessible to many rural families (Wortman and Cummings, 1978). Concern has been expressed about the exclusive emphasis of the international development community on large, capital-intensive projects which are aimed at improving rural incomes, while ignoring the potentials of improving traditional farming systems (Goldsmith, 1985). This concern focuses on our continued emphasis on conventional economic development and highly-subsidized solutions to increasing rural income, rather than a rational evaluation of how to produce food and satisfy human needs using available internal resources. A viable option is to use the resources which are present on the farm or in a region to regenerate the production potential of the soil, sustain food production and availability, and accomplish this improvement in an environmentally sound way.

Resource-efficient food production systems are designed with people in mind. The majority of farmers in most African countries are women, who carry much of the burden of production as well as reproduction. Because of their multiple roles and concerns for the family, when food production and consumption decisions are under control of women there is a greater opportunity to improve production of food and nutrition for the family. The importance of women in agriculture is a current reality in Africa, and the development of human potential as a key internal resource is a part of the total development strategy. These are some of the elements which must be considered in the design and evaluation of resource efficient farming systems and technologies.

Biological Structuring of Farming Systems

In order to understand how to better use internal resources in new or modified farming systems, it is important to consider new information which is becoming available on the biological structuring of agricultural systems (Francis and Harwood, 1985). Biological structuring is the organized interaction of biological processes which makes optimum use of the resources internal to the farm, and which takes advantage of the natural biological potentials of the living system. Much of this structuring is active in traditional, low-input agricultural systems. If these systems are better known, and if science can be introduced to explain why certain practices work well, it is possible to design even better composite systems based on a series or mixture of crop and animal species which will provide food, income, and security to the farm family.

If crops and animals are produced in an agricultural system whose biological structure is not efficient, high yields can only be achieved by massive supply of industrial inputs. For instance, a typical continuous corn production in Pennsylvania using recommended practices requires more than twice the energy inputs in the form of fertilizers, herbicides, pesticides, machinery, and labor, compared to a system where "biological structure" is altered using rotations. One high-cost component of the conventional system is synthetic nitrogen, an input which can be replaced by nitrogen fixation. It is possible to reach the same or higher yield levels in the non-chemical system (Culik et al., 1983). On the Lambert farm in the Palouse region of Washington, there has been no application of chemical fertilizers for more than 70 years. Through use of cover crops and rotations the soil on this farm has higher levels of phosphorus than neighbor's fields where soluble P is routinely applied (Patten, 1982). As one soil scientist said, "On the Lambert farm, we don't know where all the P comes from; on the neighbor's farm we don't know where it all goes!"

Energy costs in agriculture depend on the amount of production inputs used. Management of a highly structured system may be complex and require significantly greater information, management expertise, and time. This management exploits the important biological interactions between crops grown together at the same time or between crops and animals which cohabit a system. Efficient structuring is not happenstance. Over the years in both tropical and temperate zones who desired low-input, high productivity systems. This empirical knowledge is now being assembled and evaluated, and scientists and farmers are working together to link these traditional systems with technical principles.

Resource Efficiency and the Green Revolution

Much of our research and development effort over the past two decades has concentrated on the high technology models which have led to a "green revolution" in a few favored areas of the developing world. This approach has increased production markedly in these limited regions, and has benefited some of the farmers who were financially able to take advantage of the new technology. The short, non-lodging, nitrogen-responsive cereals have produced excellent yields when provided with adequate fertilizer, pesticides, and irrigation in some cases (see annual Reports of IRRI, Philippines and CIMMYT, Mexico). This has been accomplished at a high cost, and only in a limited number of areas. The current challenge is to solve production constraints in the more difficult production areas, and to work together with the farmer who has poor land, limited resources, and a need to produce food and income for the family as well as some excess for the market.

There is an approach which can be successful for low-input farmers, and this incorporates the maximum possible use of internal production resources through understanding the biological structuring capacities of natural and traditional cropping systems. This understanding is used to design new alternative systems and modifications of existing systems by combining traditional wisdom or experience with the elements of modern science. There are success stories in both tropical and temperate zones using legume cover crops and rotations, intercrop and relay crop combinations, and sequences of crop species with different rooting depths or resource requirements. These resource-efficient, alternative, organic, or low-input systems could be called "regenerative farming systems."

Resource Efficient Technologies and Alternatives

The specific technologies and examples which follow are indicative of the types of resource efficient practices which can be used to improve agricultural production using internal resources and human potential. Although they cover the most important factors in crop production -- fertility, water, pest control, genetic components, mechanization -- the list of components is not exhaustive nor are the practices to be taken as blanket reecommendations for all locations and situations. Rather, they are indicative examples of the types of farming practices which exploit the internal resources on the farm or in the region. Production constraints are overcome in a resource-efficient and biologically and environmentally integrative way, as compared to conventional technology which tends to dominate the cropping environment. There is more detail on the research requirements for application and extrapolation of results in the following paper.

1. Improving soil fertility

The green revolution solution to enhanced fertility and increased crop production has been purchase and application of soluble chemical fertilizers. This has provided short-term increases in food production in a number of sites where rice, wheat, and other crops have been planted under controlled conditions and intensive use of these and other inputs has dominated the production environment. This approach has essentially depended completely on external inputs, and the purchase of expensive chemical fertilizers at high cost to the farmer and to the country. Often based on imported energy sources, and on international capital borrowed to construct plants for fertilizer production, the increased use of commercial fertilizers may have contributed in a substantial degree to the foreign debts accumulated by some countries over the past two decades. For example, during the five-year period 1978 to 1982, Tanzania imported between 42 and 86 percent of the chemical fertilizer applied there, an amount reaching 68,492 tons in 1982 (Chowdury et al., 1983).

Other options which have been used with success include leguminous cover crops and food grain crops grown in rotations, living leguminous mulches, intercropping of cereals and legumes, use of legumes with enhanced nitrogen fixation potential, and use of leguminous trees in alley cropping patterns (Ayanaba and Dart, 1977; Brewbaker and Sorensson, 1985; Francis, 1978, 1986; IITA, 1982). Use of compost and animal manures has been effective under some circumstances (Borowski and Liebhardt, 1983). Methods of compost preparation which are potentially useful in a tropical environment were described by Ngeze et al. (1983). A number of these alternatives have been described in Tanzania in the workshop proceedings from a conference held there two years ago (Semoka et al., 1983).

The magnitude of nitrogen fixation can be impressive, from 30 to more than 300 kg/ha, depending on the legume species and the length of time it is in the field. A list of examples is giving in Figure 3 (from Table 2, Liebhardt, 1983). A number of these systems have been used in the tropics, especially the Azolla system with rice. However, much more research must be done to explore the true potentials of these alternatives under a range of moisture and temperature conditions. According to Alexander (1985), there will be a much higher potential for nitrogen fixation if better legume -- rhizobia comnbinations can be found which are more productive under stress conditions. Some of the factors affecting fixation include soil pH, organic matter content, applied nitrogen, soil water and temperature, and the specific strains of Rhizobium present. These factors were discussed by Chowdury et al. (1983).

It is important to note that much of the nitrogen applied as soluble fertilizer is lost through volatilization or leaching. Brady (1982) estimates that only 50 to 60 percent of chemical fertilizer is actually used by upland crops, while this figure may be only [illegible] to 35 percent in flooded rice. When organic forms of nitrogen are used as an internal resource, this fixed N or crop residue or compost is more available to crop plants over an extended period of time due to release of the N by microbiological and chemical processes. There is less leaching, and more of the total N eventually is available to plants. Another potential of these structured systems, when they include more than one species with different rooting depths, is the upward cycling of nutrients from lower strata in the soil. This movement of nutrients is the opposite of the continuous downward leaching movement of applied chemical fertilizers (Nye and Greenland, 1960). More research needs to be done under tropical conditions on the potentials of these nutrient sources, but enough examples of success exist to suggest that this approach would replace much of the applied chemical fertilizer and promote both better crop production and a more stable ecology on the farm and in the underground aquifers.

Figure 3. Amounts of Nitrogen Fixed by Different Kinds of Green-Manure Crops. (from Table 2, Liebhardt, 1983).

Green-manure crop	Method of cultivation	Yield of aerial parts fresh wt./ha	Nitrogen fixed kg/ha
Milk vetch	Grown for one season in winter	22.5 to 75	101.2 to 337.5
Sesbania	Grown alone for one season	22.5 to 75	112.5 to 375
	Interplanted in summer	11.2 to 30	56.2 to 150
Sunn hemp	Grown as catch crop in	15 to 37.5	60 to 150
Sweet clover	Grown for the whole year	30 to 60	150 to 300
	Interplanted at the early stage of corn	7.5 to 11.2	37.5 to 56.2
<u>Vicia sativa</u>	Grown as catch crop in winter	11.2 to 22.5	56.2 to 105
	Grown alone for one season	22.5 to 45	105 to 210
Azolla	Grown prior to transplanting rice seedlings for 20 days	22.5 to 45	45 to 90
	Grown prior to transplanting rice seedlings for 30 days	37.5 to 75	75 to 150
	Interplanted with rice for 20 days	15 to 22.5	30 to 45
	Interplanted with rice for 40 days	37.5 to 60	75 to 120

2. Efficient water use

The drought which currently threatens thousands of lives in parts of Africa is part of a long-term, cyclical pattern which recurs with some regularity in some areas of the continent. What has amplified the effects of the current drought is a higher population and a number of years of exploitive practices which have reduced the soil's capacity to hold water and make it available for crops. This includes the intensification of cultivation, the shortening or elimination of fallow periods, excessive grazing, and the removal of most organic material from fields to use as feed or fuel. Concern about loss of water is not limited to the developing world, as much of the U.S. land resource is also threatened due to excessive and unecessary erosion. In this process, the internal resources of nutrients and water which could be used for crop production are lost (Sampson, 1981).

Water is not lost from the intensively cultivated contour terraces in Burundi, where a range of annual and perennial crops are interplanted through a major part of the year. The long-term relay crop patterns which have short-cycle sorghum, millet, groundnut, or cowpea with long-cycle pigeonpea or cotton in Northern Nigeria make maximum possible use of rainfall, where a single monocrop would only be able to use the peak rains. Other intercrop patterns with maize, beans, sweet potato, and long-cycle cassava make similar efficient use of nutrients and water in the forest zone. Such intercropping systems have evolved in most regions to fit the resource base and the needs of farm families (Francis, 1986). More intensive use of new and appropriate technology has been introduced in extremely dry regions of Niger with contour terraces made of laterite or soil, smaller vee-shaped terraces for individual trees or clumps of crop plants, and other bunding operations to catch and concentrate scarce rainfall (Persaud et al., 1985). Use of Leucaena and other leguminous tree species in strips to capture wind-blown organic matter and soil, and to trap runoff water, can also reduce erosion and lead to revegetation of an area and a slowing or stopping of desert advancement or desertification (Brewbaker and Sorensson, 1985). These methods all are under test, or have been applied by farmers, to conserve the scarce water resource.

Other agronomic practices which promote the efficient use of available rainfall include increasing organic matter to hold water in the profile, use of tied ridges and contour cultivation techniques to prevent runoff and capture more water "in situ" in the profile, wider planting to concentrate available moisture on a crop in a reduced land area, and interactions of fertility with water levels. In some areas where drought was considered the most limiting some areas where drought was considered the most limiting factor (eg. Mali, with rainfall of 300 to 600 mm), it appears from recent studies that nitrogen may actually be most limiting (Winn, 1985). The interaction of these two factors is important to understand. If N is limiting, some process such as the ones outlined above must be used to increase total dry matter or carbon production; this in turn will promote more organic matter in the soil and increase the ability of the soil to hold water. But the land must be protected from overgrazing, removal of all crop residues, or even removal of all the weeds -- which can contribute significant amounts of organic matter.

These alternative ways to make more effective use of existing rainfall appear to be much more cost effective than the giant irrigation schemes which have been proposed and financed in the past. The silting of dams and delivery canals, lack of proper management of irrigation facilities and equipment, and the sheer cost of these large schemes suggest that we should explore the potentials of systems based on the internal resource: rainfall used on the farm where it falls!

3. Weed, insect, and pathogen control

Green revolution tehcnology has provided a package for control of pests as well as other factors in the production environment. These chemical controls work well under a carefully controlled environment, and when climatic conditions are right. This approach has been expensive, and requires a sophisticated level of management with new potential side effects of large scale production of agricultural chemicals were made tragically clear by the recent disaster in Bhopal, India. Thus, we need to seed alternative methods to control pests. These methods should depend more on internal resources and biological processes which may be more easily understood and applied by the farmer.

Alternatives to weed control with herbicides include crop rotation, careful and timely cultivation, intercropping or relay cropping to out-compete weeds, selection of allelopathic species which suppress weed germination and growth, and rotation of crops with pastures and other perennial species. Many of these potentials were reviewed by Altieri and Liebman (1986). One or more of these intensive multiple cropping practices will be useful under a wide range of cropping situations, and many of these practicices are already used by farmers. Ninety-eight percent of the cowpea production in Nigeria, for example, comes from multiple species systems. More than 50 percent of the maize and 80 percent of the beans in Latin America are produced in multiple cropping systems, and these contribute to weed control through competition for growth resources (Francis, 1978).

Since the spraying of chemicals on crops which are infested by insects provides dramatic effects which are easily observed by the farmer, and since this approach has been promoted with advertising and demonstration by the pesticide industry, this practice has been growing rapidly in developing countries. However, there are other alternatives for both insect and pathogen control which depend more on local resources and farmer management of these elements in the local environment. These include crop rotations, choice of reistant crops, timely harvest, and careful management of residues. One outside resource which can be valuable is a new disease-resistant or insect-tolerant variety of a crop already grown by the farmer. If this a self-pollinating variety, or an open-pollinated population of a cross-pollinated crop, the seed can be selected and saved by the farmer for future planting seasons.

The principles of integrated pest management (IPM) are needed for control of insects, diseases, and weeds on farms with limited resources. In application of these principles, it is important to understand economic levels of damage, alternative methods for controlling pests, and the consequences of these alternatives on the crop quality, environment, and health and safety of the farm family. Current research is providing much more information and new assessment methods which can be interpreted and applied under limited resource conditions.

4. Genetic potentials of varieties and hybrids

Use of resistant or tolerant varieties of crops can be a viable alternative for the limited resource farmer for controlling insects or diseases. Maize streak virus in West Africa, the most limiting disease in that region, can be economically controlled with new cultivars of maize coming from the program at IITA (1982). More efficient use of nutrients or water is possible through new genetic strains of cereals such as sorghum and millet. These are only now under development, but encouraging results have been seen in sorghum nurseries in the Western Sudan during the past three growing seasons at El Obeid (Winn, 1985). Sorghum selections tolerant of high-aluminum soils have been selections tolerant of high-aluminum soils have been developed in a program at CIAT in Colombia in collaboration with the national program (Gourley and Flores, 1985).

These types of genetic changes are easily introduced into existing cropping systems, if the grain type of the new variety is acceptable to the farm family and to the market, and if the new variety appears to meet other perceived constraints. Use of new genetic material is one of the most cost-effective ways to introduce new technology. Shorter-cycle rice varieties have made possible the cultivation of two and even three crops per year where water is available in Asia. In some areas, the rice can now be followed by a shorter cycle cash crop such as mung bean or sorghum using residual moisture after rice. The "high yielding varieties" of the green revolution have been the keystone of those changes in crop production. There is a growing interest in the development of varieties specifically adapted to multiple cropping systems (Smith and Francis, 1986). A new generation of varieties and hybrids adapted to marginal conditions and to intercropping could be the start of a new revolution aimed at meeting the needs of the majority of limited-resource farmers in the developing world.

5. Mechanization potentials

Greater efficiency of labor has been achieved in a few selected zones with the introduction of medium- and large-scale machinery into farming. This often is out of reach for the farmer with limited resources, either because of cost or physical inaccessibility. It may also be cost ineffective for a farmer to contract land preparation for small plots of land, and to have this work done at a less than optimum time because the rental tractor and implements are directed to larger jobs or to the owner's lands when conditions for tillage and planting are optimum.

Other options have been developed to aid in some of the farm operations. Small tractors developed in Japan and Taiwan have been effective in reducing labor inputs in much of South Asia. Planting, weeding, harvesting and threshing machines using hand or foot power or small engines have been developed by IRRI (Philippines) and IITA (Nigeria) (see annual reports from these centers). A mechanized jab available. The Botswana tool bar, developed from a second-hand vehicle axle and two wheels and tires has been used with some success in parts of Southern Africa.

These example all provide evidence that the road to mechanization is not only possible through large power units or sophisticated machinery., It is far more important to have equipment which is small in scale, can be built and repaired locally, and for which parts can be built or approximated in local shop conditions. Large cast items which can only be repaired with great difficulty or replaced entirely after a long and expensive wait should be avoided. The small, multiple part equipment where each component can be copied in a shop is the type preferred. Such appropriate technology has been designed and publicized by the Intermediate Technology Design Group in the U.K.

How to Reach These Potentials

A number of elements need to come together to reach the potentials of the new or modified systems outlined in the preceeding section. One is a concerted effort in research to provide a technical basis for new recommendations. The farming systems approach to research is an indicated methodology. This procedure as well as more precise research priorities are outlined in another discussion paper. There are important policy implications in the quest for a resource-efficient agriculture. Some of these are causal, in that decisions at the national and regional level can promote the development and use of more efficient systems. Other policy implications are the result of a successful implimentation of a resource-efficient farming approach in a wide area of a country. These apsects are presented as a series of questions on critical issues in policy which must be addressed, and are listed in another discussion paper.

There is need for close participation of all agencies active in the development process. This includes government agencies, private voluntary organizations (PVO's), and other non-government organizations (NGO's). Their potential contributions to the system, as well as their role as clients for information are explored in another paper in the series. Finally, the critical role of information is discussed. Since information is crucial to all resource-efficient systems, and since it is central to the development of research priorities, a brief introduction is presented here. A more comprehensive treatment is given in another discussion paper.

The process of information exchange and communication among researcher, extensionist, and farmer depends on adequate and timely activities in this area. Critical to the discovery, development, and application of new and resource-efficient farming systems and technologies is their characterization and interpretation in terms which can be easily understood and implemented by farmers. Most foreign-financed assistance programs will not reach farmers directly, but will attempt to multiply the effects of their efforts through extension agents or volunteers who workd directly with farmers. The collection, screening, packaging, and distribution of information to these change agents is crucial. Many of the existing best practices which are resource efficient and approprriate to farmers with limited resources are not publicized or extended through the existing channels of information. A new network is needed, or a new agenda in the existing networks, to make this appropriate technology available to those who will apply the practices. Workshops, regional meetings, training sessions, and both conventional and non-conventional publications are needed to help involved people share the available information. The management of this vital resource is discussed in detail in another paper.

Conclusion: A Plan for Action

As outlined through this background paper, what is needed is a careful evaluation of those resource efficient practices which have worked under farm conditions, the description and packaging of information on how to make them work, and the mobilization of people through an extension service or voluntary agency to help this information reach the people who need it. The farming systems research/extension approach was described as one mechanism which would appear to be an effective route to developing information in the limited resource environment and moving this information to the farmer. There are a number of models which have been tried, and even some which are of modest scale which have been successful. It is important to sort out these models and build on the experience which has been gained in those which have been successful.

A recent Office of Technology Assessment (1984) report on issues in technology and agriculture for Africa stated that, "A concensus is emerging on the kinds of technology most needed to meet Africas's future food needs. Participants in OTA's workshop described these technologies as: low-risk, resource-conserving, small-scale, locally produced, affordable, easily repaired, and based on traditional methods." Some of the traditional technologies which have been mentioned in this paper include multiple cropping (intercropping, relay cropping, double cropping, and others), ally cropping and agroforestry with leguminous trees which fix nitrogen, cover crops and minimum tillage techniques, water conservation within the profile and on the farm, and integration of crop and animal activities. Some of this information is available and has been tested on farm, but other potentials of resource-efficient systems are yet to be explored. A number of these topics are expanded in other papers in the series.

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Additional points covered in presentation
and not covered in original paper:

1) Even in U.S. agriculture the focus of farmers, researchers and extensionists is increasingly in the use of reduced inputs, crop rotations and legume nitrogen fixation to increase overall profitability.

Key discussions in depth:

Winter: Would you say that right now we are in a position to be able to identify some technologies which are suitable for simple adaptation in countries and then extension, or are we talking about a process now of more fundamental research in trying to figure out these very complex systems in figuring out how we might intervene. I guess I am looking for the timeframe that we are looking at when this concept could have some impact in different environments, particularly in Africa.

Francis: I think if you were to pose that problem to the average researcher in the U.S. and overseas, the tendency would be to study it to death. They do a number of years of study in one location because travel is limited. They get all the fine tuning in, and then maybe even still, be a little conservative about coming out with recommendations. I think we need to accelerate all of this; we've got to do all of the above and we have to do it all at the same time. If something is successful; if it is being used, I think we have to capture that in whatever way, hire that person, and make him an extension agent or capture that on videotape and use it to show other people or bring people to that farm and use that as a demonstration.

At the same time we need to get a better understanding of biological structure or whatever, but I don't think we have time to study things to death, and that has been our tendency in the U.S. research establishment.

Morgan: I think perhaps the way in which we have done it is not necessarily the model, but it may shed some light from U.S. experience that may be helpful in avoiding pitfalls. The Regenerative Agriculture Association has taken both tasks marked in what we are doing with U.S. farmers. In publishing the New Farm Magazine, we looked at that as a two-way communication with farmers, and we receive a very high percentage of our 70,000 some subscribers corresponding with us in some way on an annual basis.

What we are looking for are two things: we are looking for the immediate potential of the practice rather than developing a sophisticated technology. Putting the farmer in referral to another farmer is an extremely good strategy. On the other hand based on what the farmers have told us they need to know in order to deal with their problems, we are also presenting, for example, to the Sobin group with ARS at USDA a list of things that the farmers say they need to understand to help push, to help drive the research system in a specific direction.

Scarborough: Agriculture has a dual object and that is increased production over cost and at the same time soil-water conservation. In many parts of Africa where you have a Bushfallow system or Swidden agriculture, the long fallow periods because the population, human as well as animal, have been cut back and are being cut back to the margin. We also look for possible solutions. Do we see in the regenerative agriculture context an answer to the Bushfallow system that in many parts of Africa is no longer operative and no longer cost-effective, and is this something that is similar to the work that is being done, say at Ibadan in Nigeria with the farming systems and also their cropping systems to attempt to reduce the Bushfallow systems.

Francis: I think you have hit it exactly. Obviously, we are not going to conserve everything nor could we afford to conserve all the resources or should we. On the other hand, we've gone so far the other way, we've exploited everything to try to produce as much food as possible, and in the process, we've lost in many places, the production resources. So what we are talking about in a way is that, you pointed out I think, we are trying to integrate some of the principles of the fallow system of this regenerating period into an annual cropping system where we introduce components such as legumes or whatever. So we bring some of these principles from the Bushfallow into the more intensive cropping system. That's an interesting way to look at it.

Summary of other discussion:

Patterson: Looking at the farmer as a client is an enormous task. One problem with the extension service, when it does exist, is that it sometimes attempts to reduce the farmers options.

Sarles: Do particular national or donor institutional structures lean more to the left or to the right of the chart?

Rodale: We need new institutions with different mindsets. At the same time, we do have a good relationship with the land grants and other institutions and we want to continue that.

Francis: The commodity approach is often not an information exchange. U.S. research and extension services are not necessarily good models for us to export. The institution question is very important.

Kamenetzsky: There have been many comments on the education necessary to stimulate this regenerative philosophy. If we want to prepare strategies to encourage ideas from the left side of the chart, we need to think about regenerating the educational process.

Rodale: That is the very purpose of my little diagram. It allows, even stimulates people to break out of the existing paradigms developed in traditional training programs. We need to develop a similar chart for education.

Carr: Change is important. We shouldn't necessarily not consider introducing something even if it seems mind boggling. We need different approaches to research. While the farmer can experiment with the combinations or management of technologies, some things require long term work, such as genetic selection.

Blobaum: Lack of information is typically the main reason that farmers do not convert earlier. Where is the best place to get information on different systems? From farmers, organizations and publishers such as Rodale Press. Not from extension agencies. Farmer to farmer is most effective.

Morgan: Farmers move faster and are the real innovators. We need to find them. They are the real diamonds in cow dung.

Francis: We've come back full circle to the packaging question. Finding the way to develop one's own system is difficult but it's where we are headed -- both in this country and abroad.

RESEARCH NEEDS FOR SOIL FERTILITY AND THE DEVELOPMENT OF RESOURCE EFFICIENT TECHNOLOGIES

W. Leibhardt, C. Francis, and M. Sands

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Rodale Research Center

INTRODUCTION

"You can identify the experiment stations in West Africa from a 727 flying at 35,000 feet!" We often hear this description of the differences between conditions on research stations and on farms in this region. The straight field boundaries and access roads, the cleared section of land in the middle of trees and "bush", and the obvious monoculture crops are seen in stark contrast to the neighboring fields. The surrounding lands operated by small, often resource-limited farmers are characterized by crop and animal diversity, multiple species systems where different niches are occupied by different crops for different purposes, limited or no mechanization for land preparation and crop culture, and a near absence of chemical fertilizer or pesticide inputs.

Outside of a few favored areas, the technology developed on research stations has not moved to the farm. Given the differences between the two environments, this is not surprising. A generation of agricultural scientists, trained by the agricultural universities and advised by experts in the application of science and technology, has tried to transform traditional agriculture by recommending monoculture techniques and high-input crop culture. This has been unsuccessful in most areas, and our technology has not reached the majority of the world's farmers. What are the alternatives, and what does science have to offer?

This background paper outlines the research needed to improve our understanding of the structuring of biological low-input systems under a wide range of conditions in the developing world. There is a growing interest in using these biological structures in the development of resource-efficient technologies. The required synthesis of existing information in such areas as soil fertility, efficient water use, pest control, varietal development and appropriate mechanization are described in this paper, with a special emphasis on Africa.

As suggested in the description of differences between existing experiment stations and farm conditions, there is a critical need for more emphasis on testing under farmer conditions. The farming systems approach appears to have proven successful under a range of conditions in Africa, and this methodology deserves to be extended to more projects. This requires involvement by a range of specialists in different disciplines, as well as organization and leadership by people with a good overview of constraints to production and their potential solutions. In summary, the research priorities for the development of resource efficient technologies for low-input farmers are described on the following pages. This is a practical outline for implementation of the principles given in the first paper on internal versus external resources in agriculture, and the second paper on resource-efficient farming systems and technologies.

Understanding Biological Structuring of Low-Input Systems

A limited but growing body of information on the biological structuring of agricultural systems is emerging from some innovative research centers. Much of the interest in the U.S. and elsewhere is beginning to focus on low-input or non-chemical farming systems. The conversion experiment at the Rodale Research Center, for example, is comparing a conventional intensive chemical fertilizer and pesticide treated crop rotational system with two non-chemical alternatives: one rotational system using animal manure and one with no inputs other than nitrogen fixed by legumes and other organic matter from crop residues. Basic studies are evaluating the cycling of nitrogen and carbon in the systems, as well as the micro-flora and fauna which develop in each system. Several conclusions are emerging. Although there is a higher weed population and biomass in the nonchemical treatments, these weeds do not affect yields of commercial crops. There is an extensive buildup of soil microorganisms, and a resulting improvement of the tilth and water holding capacity of the soil.

There are important lessons emerging from this work and parallel studies at other sites. Rotations of crops, especially cereals with legumes, break up the weed growth and reproductive cycles and reduce their presence and competition with crops. This counter-cycling approach to weed control can be used in crop rotations, in alternating wet/dry or hot/cold seasons, or in upland/lowland cultural situations in the tropics.

Intercropping or relay cropping of dissimilar species during the same year can lead to greater dry matter production, more continuous cover on the land to reduce or prevent erosion, greater competition with weeds, and some cultural control of insects and pathogens (Francis, 1986). The culture of crops with widely dissimilar rooting habits and uptake needs for principal growth factors can make better use of water and nutrients through a greater part of the total year. And crops with different depths of rooting can tap different strata of the soil volume -- some deep rooted crops can actually perform as "nutrient pumps" which tap growth factors from lower strata and bring them toward the surface where they can be absorbed by crops with shallower root systems.

Increasing the organic matter content of the upper horizons in the root zone can help absorb water during heavy rainfall, prevent runoff and excessive leaching, and maintain that water for subsequent crop growth. Analogous to naturally occurring ecosystems in the tropics, when nutrients are tied up in living or decaying organic matter they are not easily leached from the profile. Thus they are more available for subsequent cropping cycles, reducing the need for external inputs of fertilizers at high cost.

The biological diversity of multiple cropping systems can be a significant barrier to insect infestation and to pathogen spread (Altieri and Liebman, 1986). this review outlines a number of reports from the literature where insect populations have been reduced by multiple species systems. The evidence for reduced plant diseases is less abundant, but the majority of reports indicate that there is less disease problem with multiple crops than with monoculture. Thus, integrated pest management and the resulting potential for reduced or no chemical treatment is enhanced by these contributions of the biological structuring of the cropping system.

There are indications from the Rodale Research Center's conversion experiment and other reports that non-chemical systems are quantitatively different than those we have been studying with heavy inputs of chemical fertilizer and pesticide application. With the buildup of soil microorganisms and earthworms, detritovores, and other insects, there is a more rapid cycling of soil organic matter, thus making these nutrients more quickly available to crop plants. Coupling the greater production of biological material from multiple cropping systems each year with this more rapid cycling of organic matter, the soil fertility is enhanced for crop growth in an increasingly sustainable manner. This is truly a regenerative system, improving the fertility status of the soil while permitting crop growth and food production with a much reduced cost for inputs -- using instead the internal resources available on the farm.

Much is yet to be learned about these biological patterns in major food crop systems in the tropical and subtropical regions. Differences in temperature pattern -- where there are no killing frosts in winter -- and in seasonal rainfall may cause different types of cycling. It is certain that in lower rainfall regions the interactions are greatly reduced during the dry season. Yet there is much to be learned about how to use that rainfall which is available, and to concentrate its uptake and conversion by crop plants to feed humans and other animals in the system.

The Need for Resource Efficient Technologies

Overview:

The most appropriate resource-efficient technologies for the African farmer are those which improve existing farming systems rather than attempting to transform them in a major way. In addition to being easily understood and to solving production constraints which are perceived by the farmer, these technologies should "reflect local conditions, be affordable, locally produced and repairable, and involve low risks and low inputs" (Office of Technology Assessment, 1984).

For the purposes of this paper we have grouped these technologies into five major headings.

1. Soil fertility
2. Efficient water use
3. Pest control (insects, weeds, pathogens)
4. Varietal development
5. Appropriate mechanization

Soil Fertility

Technologies which promote the efficient use of resources internal to the farm are most desirable. One option to the importation of expensive nitrogen fertilizers is the introduction of alley cropping. The planting of leguminous trees in recurrent rows at a regular interval across the field can provide nitrogen through fixation, as well as mulch for growing annual crops, fodder for cattle or smaller animals, and firewood for cooking. On erosion prone slopes, the woody perennials can be planted on the contour to reduce soil loss and the nutrients which leave with the soil. Leucaena and Glyricidia are two species which have proven useful, and there are more than 800 other species of legumes and non-legumes which also have been shown to fix nitrogen. Although more research is needed on these perennial species, they are already playing an important role in reducing erosion and providing nitrogen in Rwanda and elsewhere (Brewbaker and Sorensson, 1985).

Gliessman (1980) presented an excellent review on the advantages and disadvantages of multiple cropping. In areas of the world where multiple cropping is a common aspect of agroecosystem management, it has been shown generally that productivity is more stable and constant on the long term (Gliessman and Amadar, 1979; and Wilkens, 1974).

The farmer is often able to achieve a combined production per unit area greater with a crop mixture as compared to an equal area divided among the separate crop units. In such cases the Relative Yield Total (RYT) is greater than 1.0. It may be that each crop in the mixture yields slightly less than the monocultures, but the combined yield of the mixture of crops on less total land area is the important aspect.

In a study by Trenbath (1974) the results of 572 comparisons of crop mixtures demonstrate that the majority (66%) had RYTs close to 1.0, indicating no distinct advantage to the mixture (Figure 1). On the other hand, 20% of the mixtures had RYTs greater than 1.0, ranging up to 1.7, indicating advantages to the mixtures, and only 14% had less than 1.0, indicating distinct disadvantages. It must be remembered that most of the cases studied were experimental planting, and not many cases of actual multiple cropping systems. Farmers would tend to choose the systems which yield more.

Mixed cropping is little used at present in intensive agriculture, but despite the promotion of sole cropping by Extension agents, the majority of East African farmers still practice it. Tree crops, cereals or root crops are interplanted with short-term legumes such as beans, groundnuts, cowpeas, peas, etc.

There is little experimental evidence of the benefits of legumes in mixed cropping. However, Osiru and Willey (1972) and Willey and Osiru (1972) indicated that, in Uganda, there is a possible yield benefit by mixing maize and beans or sorghum and beans under intensive farming. Yields of maize-beans and sorghum-beans mixtures were up to 38 percent and 55 percent more, respectively, than the combined yield of each component of the mixture when grown separately. It was concluded from the Uganda experiments that yield increases occurred because the mixtures better utilized the environmental resources, such as light, and the dissimilar rooting depths of the different crops exploited the soil more, with above-ground competition being reduced by the heterogenous growth cycles. However, some long-term benefit to the fertility status of the soil from nodulation and nitrogen fixation cannot be ruled out.

Although most grain legumes will use most of the nitrogen which they fix in a given season, the leaf fall and later deterioration of stems and nodules provide additional organic matter and nitrogen to the system. Likewise, straw and other residue from cereals which is left in the field provides a mulch for succeeding crops as well as nutrients as this organic matter breaks down. Unfortunately, this crop residue may be removed for fuel or cattle feed, and the manure not returned to the field. These practices need to be reversed when possible, by providing alternative sources of fuel and by setting up integrated crop/animal systems to the maximum benefit of both and of the family.

Preliminary work in Kenya has shown that pure stands of maize and beans yield 3,500 kilograms per hectare and 1,000 kilograms per hectare, respectively, while the mixture produced 3,200 kilograms of maize and 600 kilograms of beans. Intercropping is, therefore, an area of research which needs urgent attention, because, as the holdings get smaller and farming becomes more intensive, mixed cropping probably has the greatest potential to supply a family farm with a steady cash flow and food supply throughout the year. Since legumes already fit very well into mixed cropping systems, nodulation and nitrogen fixation in an altered ecosystem of mixed crops merits more attention.

Amadar (1980) documented a system in Tabasco, Mexico. Corn is planted at a density of 50,000 plants/ha, climbing beans in the same hole at a density of 40,000 plants/ha, and the squash intermixed among the rows of corn and beans at a density of 3,330 plants/ha. All are planted at the same time in this case. Beans begin to mature first, using the corn stalks for support; the corn matures second; the Squash is the last to mature. Aerial space is divided such that corn occupies the upper canopy, beans the middle, and squash covers the ground in between. Better weed control is achieved, and insect pests are largely controlled by natural enemies. Corn yield was significantly higher for the polyculture as compared to different densities of monocultures, but beans and squash suffered a distinct yield reduction. Interestingly, the LER (Land Equivalent Ratio) value of 1.73 tells us that the sum of the yields in the mixture can only be equalled in monoculture by planting 1.73 times the area divided proportionally among the three sole crops. The advantage of producing a greater yield altogether on less land is obvious. The much higher total yield of biomass in the mixture is also very important, because much of this organic matter is returned to the soil, bringing important consequences in soil fertility, humidity conservation, microbial activity, etc., all related to the success of the following crops.

When total complementarity is achieved, the roots of the component species occupy different soil horizons, reducing considerably the potential competition between species, and increasing the efficiency of total nutrient uptake. In combinations of deep-rooted with shallow-rooted species, especially when trees are planted with grasses or annual crops, the trees are capable of absorbing uncaptured nutrients as they are leached into the soil. Then, through their transport to foliage, they can be deposited on the soil surface again with leaf drop.

Intercropping systems have been shown to definitely extract more nutrients from the soil than do single crop plantings per unit area of land. In a very complete study with corn and pigeon peas in Trinidad (Dalal, 1974), various parameters of crop response were measured. Highest single crop yields of grain were obtained in the monocultures, but by summing yields of the two crops planted mixed or in intercropped rows, relative yield totals (RYT) were always higher. Total dry matter production was higher in the mixtures as well. The most interesting aspect is the uptake of nutrients (N, P, K, Ca, & Mg). The total uptake is based on the sum of the two crops together, and in all cases the total nutrient content of the dry matter production was higher for the mixtures, demonstrating the greater extractive capacity of the multiple cropping system. Research is needed to assure that these sytems can be fed over the long term under more intensive conditions.

Efficient Water Use

The practice of tied ridges in a row planted cropping system can capture the majority or all rainfall by preventing runoff and storing this moisture in the soil profile where it can be used directly by the growing crops. This is superior to complicated large-scale irrigation projects, or even to local catchment basins which are relatively labor and capital intensive to construct and more difficult to maintain. There are losses of water during transport to the field where it is needed, and losses to evaporation in storage. The tied ridges have been used in Niger, Mali and other parts of West Africa where rainfall is scarce (Persaud, et al. 1985). A recent innovation to prevent evaporation from large bodies of water is the use of discarded tires filled with empty glass bottles -- these tires float on the reservoir, can be covered with plastic, and prevent most water evaporation from the water surface -- this is converting a waste product to a resource, and has proven successful in Australia.

Pest Control

Control of pests is an important part of practical agricultural production systems. Weeds, insects and diseases account for significant losses during the time the crop is in the field and during transport and storage before finally being consumed. Regenerative technologies can be considered as using information and knowledge to minimize losses due to pests, and at the same time reducing input costs, environmental and health costs.

In the U.S. from the 1940s to the present, crop losses due to insects have increased nearly two fold (from 7 to 13%) in spite of a more than 10 fold increase in insecticide use (Pimental, et al., 1978). Georghiou (1980) documented that 432 species of arthropods, 50 species of plant pathogens, 5 species of weeds, and 2 species of nemotodoes have become resistant to one or more chemicals. Of the resistant arthropods, 60% are injurious to agriculture and 40% are pests or vectors of diseases of man or other animals.

Research in Brazil by Paschoal (1980) shows clearly what happens in a tropical agroecosystem when chemical control agents or biocides are introduced to control insects and diseases. The results are quite clear cut and show that spraying with chemical biocides increases the number of diseases and insects that must be controlled.

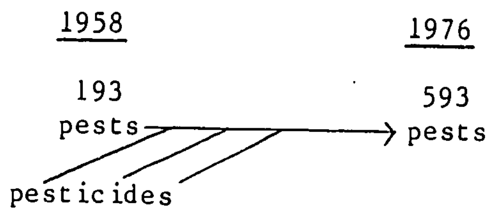
Paschoal was educated at Ohio State University and returned to Brazil to do research on corn. He was not able to control insects using biocides and became intrigued as to why this was a problem (personal communication 1984). He then assembled data on 37 major crops in Brazil from 1958 to 1976. Biocides were not used on these crops in 1958, however, by 1976 use was intensive. The data follows in table 1.

TABLE 1. Crops, pests as as influenced by pesticides and year.

CROPS	Number of Pests 1958	1963	1976	Increase in Pests 1958-63	1958-76
Totals 37 crops	193	243	593	50	400

Excerpted from Table 5, Pragas, Praguicidas e a Crise Ambiental: Problemas e Solucoes by A. D. Pashoal, Ph.D.

Overall we can write the following general equation for what happened in Brazil to 37 crops from 1958 to 1976:



In those eighteen years after the introduction of biocides insect and diseases increased substantially leading most likely to more spraying.

The U.S. and Brazil experience would strongly suggest alternative approaches to chemicals such as resistant varieties, multiple cropping, rotations and other cultural and biological measures to control pests.

Gliessman (1980) suggests mixed cropping systems as one approach. This comes about because the mixed cropping system (1) prevents spread of diseases and pests by separating susceptible plants, (2) one species serving as a trap crop, protecting the others, (3) associated species serve as a repellant of the pest or disease to which the other crops are subject, and (4), a greater abundance of natural predators or parasites of pests due to a higher diversity of adequate microsites and alternate prey. However, we can site reasons for which a multiple cropping system may be more susceptible to attack: (1) reduced cultivation and greater shading due to the presence of associated species, (2) associated crops serve as alternate hosts, and (3) crop residues from one crop may serve as a source of inoculum for the others. All of these advantages and disadvantages can exist, and much further study is necessary to achieve the combinations which give the most positive results.

A few examples might serve to demonstrate the specific potential of multiple cropping for biological control. In one study it was shown that the planting of a locally used medicinal herb (Chenopodium ambrosioides) in sequence with corn or beans, reduced the incidence of nematode populations in the soil, demonstrating a potential for reducing attack on the roots of the bean and corn crops. Substances toxic to the nematodes were liberated into the soil by the herb, wherein the nematodes were inhibited. In another study, yields of cotton untreated with insecticides, but interplanted with sorghum, were 24% higher than the sprayed monocultures. The reason was that sorghum served as microhabitats for cotton bollworm predators. In another case, fall army worms on corn associated with bush beans were less a problem than on pure-stand corn. In an incidence in which beans intercropping with corn were attacked less by rust as compared to beans in pure stands, it is felt that corn functions as a barrier to the dissemination of the fungal spores.

Maize-bean intercrops have shown reductions of fall armyworm on maize and Diabrotica beetles on bean in replicted trials in Colombia (Altieri, et. al 1978). Similar examples have been shown with African crops to limit insect infestation through cropping system manipulation (Altieri and Liebman, 1986). This is superior to chemical control, reducing costs and potential risk to the environment and the family.

Weeds, on the other hand, present another problem. It has been reported that weeds are much less a problem in multiple cropping systems, especially in intercropping, the idea being to occupy the space normally available to weeds with other crops. The aggressive nature of weeds is well known, but recent work has begun to show that weeds can fill an important ecological role in cropping systems, by capturing unused nutrients, protecting the soil, altering soil fauna and flora, serving as trap plants for pests and disease, and changing the microhabitat to allow for high populations of pest predators and parasites. The understanding and use of a "non-weed" concept by farmers in rural tropical Mexico, where each is classified according to positive or negative effects, demonstrates that we need to understand in more detail the biological functions of each component of the agroecosystem in order to establish the structure that will allow adequate weed, pest, and disease control. If part of this control can be achieved by merely manipulating the crop mixture in time and space, great strides towards a more efficient agricultural management can be made.

Varietal Development

Genetic control of insects and pathogens is a logical approach for resource-efficient and low-input cropping systems. When the resistance can be built into the genetic package, this is an inexpensive and cost-effective way to introduce control to a large number of farmers. Yet the varieties or hybrids must meet the needs of the family and be acceptable on the market. Maize streak resistance in new hybrides (IITA Annual Reports, 1982, 1983) and cassava mosaic virus resistance from the same center are beginning to have an impact on production of these two basic food crops in Nigeria and elsewhere in West Africa.

The genetic variability in resistance to *Striga* in sorghum is being exploited in Sudan to attempt to solve this serious constraint on production of a basic grain. The parasitic weed drastically limits production or sorghum where this is the staple food. Only a team effort by physiologists, pathologists, and plant breeders has made this research progress possible.

Another area for varietal development is in the development of crop varieties that produce under the lower soil fertility regimes so common in the tropics. Certain crops grown exclusively in the topics normally grow at pH levels which would kill corn or soybeans (Sanchez, 1976). Pineapple is perhaps the best known example, but coffee, tea, rubber and cassava also tolerate very high levels of exchangeable aluminum. Among the pasture species, several grasses and legumes are apparently very well adapted to acid soil conditions. Tropical grasses such as quinea grass, *Panecum maximum*; jaraqua, *Hyparrhanea rufa*; molasses grass, *Melinia multiflora*, and several species of the genera *Paspalum* and *Brachiaria* grow well in very acid soils.

Legumes are considered very susceptible to soil acidity because of their high calcium requirements for nodulation, however, several tropical pasture legumes are strikingly well adapted to acid conditions. *Stylosanthes spp. Desmodium spp*, *Centrosema spp*, *Calopogonium spp*, and tropical Kudzu, *Pueraria phaseoloides* are the principal ones (Sanchez, 1976). Among the grain legumes, cowpeas and pigeon peas are more tolerant of acidity than field beans and soybeans.

Many of these species have evolved in acid soils and have genetic properties which tolerate conditions associated with high aluminum levels. On the basis of their research, Spain et al. (1975) have produced a list of species adapted to high soil acidity and aluminum (Table 2.)

TABLE 2. Crops and Pasture Species Suitable For Acid Soils With Minimum Lime Requirements

Lime Requirement (tons/ha)	Al Saturation (%)	pH	Crops (Using Tolerant Varieties)
0.25 to 0.5	68 to 75	4.5 to 4.7	Upland rice, cassava, mango cashew, citrus, pineapple, Stylosanthes, Desmodium, kudzu, Centrosema, molasses grass, jaragua, Brachiaria decumbens, Paspalum plicatulum
0.5 to 1.0	45 to 58	4.7 to 5.0	Cowpeas, plantains
1.0 to 2.0	31 to 45	5.0 to 5.3	Corn, black beans

In a review of tolerance to aluminum, Foy (1974) concluded:

1. Some Aluminum-tolerant varieties keep developing and are not injured.

2. Some aluminum tolerant varieties increase the pH of growth medium which reduce availability of aluminum whereas sensitive ones decrease soil pH compounding the problem.

3. Some tolerant species accumulate aluminum in their roots or translocate (transport) aluminum at a lower rate to the top.

4. Aluminum in roots does not inhibit the uptake and translocation of calcium, magnesium and potassium in tolerant varieties, whereas it does so in sensitive varieties.

5. High plant silicon is associated with aluminum tolerance in certain rice varieties.

6. Aluminum tolerant varieties do not inhibit phosphorus uptake and translocation as much as susceptible varieties or species. Also many aluminum tolerant species or varieties are very tolerant of low phosphorus levels.

Cassava Manihot sp., a tropical root crop growing widely on very infertile soils that are frequently acid, has acquired the reputation for being a crop that yields well under very low fertility conditions (Cock and Howeler, 1978). They conclude that cassava tolerates low soil pH and high levels of aluminum and manganese as well as low levels of soil calcium, nitrogen and potassium better than many other species. While it has a high phosphorus requirement for maximum growth, it can utilize phosphorus sources that are relatively unavailable to other plants. It is highly tolerant of uncertain rainfall patterns and is an extremely efficient carbohydrate source on low fertility, acid soils with low levels of fertilizer applications. Cassava yields of 36 metric tons per hectare per year have been obtained under conditions that are suboptimal for many crops.

Rachie (1978) states that an estimated 1.57 million people live in the tropics and this number is likely to expand to five billion in fifty years. This rapidly growing population will have to increasingly rely on plants as sources of both energy and protein. In the semiarid to subhumid climates, two-thirds of dietary calories come from cereals while in the humid tropics the bulk of dietary carbohydrate comes from roots and tubers. The production of starchy root and tuber crops is inherently more efficient than the production of cereals, especially on marginal lands and/or land with minimal external inputs. It is estimated that with roots and tubers, at least two to three times more caloric energy can be produced per unit of land and time and with only one-third to one-half the production cost of cereals. It is, therefore, suggested that an increasing proportion of human energy needs will be derived from starch roots and tubers.

Plucknett (1978) in a review article suggests that sweet potatoes (Ipomoea batatas (L.) Lam.), long associated with poor people and less productive soils, may be one solution. There is good reason that the sweet potato is grown so widely under such difficult conditions.

Fox et al. (1974) found that sweet potato had one of the lowest phosphorus requirements of the crops studied (Lettuce, Lactuca sativa; corn, Zea mays; and Chinese cabbage, Brassuca pekinesis).

The International Rice Research Institute (IRRI) 1972, classified varieties of rice that are tolerant to sensitive to low phosphorus. They are also selecting varieties for tolerance to iron deficiency or toxicity and the presence of toxic soil reduction products.

In summary, it is apparent that high production can be achieved on rather hostile soils with selection of tolerant species or varieties of plants. This would be a stratagem which relies on no or minimal inputs and yet can increase food production substantially.

Appropriate Mechanization

An example of locally developed and produced technology is the Botswana tool bar, a multi-purpose tool bar which can be used for primary cultivation, planting, and weeding -- and during the year can be used as a cart for basic transportation. Constructed from abandoned vehicle axle and wheels, each tool bar can provide several families with these agricultural tools at a minimum cost. Local shops can construct most elements of the machine, and thus can produce repair parts and perform routine maintenance. There are no complicated parts nor an engine to maintain and fuel -- the implement uses animal power and is a simple improvement on the animal traction implements already in use in the area (ATIP, 1984).

These are but several examples of resource-efficient farming practices which concentrate on use of internal resources available on the farm as substitutes for external imported resources. There are many more examples, and some of the most successful ideas will come from African farmers themselves. A systematic search and collection of successful regenerative practices will often lead to the identification of the best alternatives in the region, and the communication of this information to others who need it.

The rapid development of these resource efficient technologies will depend on an efficient use of the existing extensive, though often fragmented, information in each of the five mentioned areas. As an example of the information available for potential use in the design of regenerative technologies, the following section presents a more in depth discussion of one heading -- soil fertility.

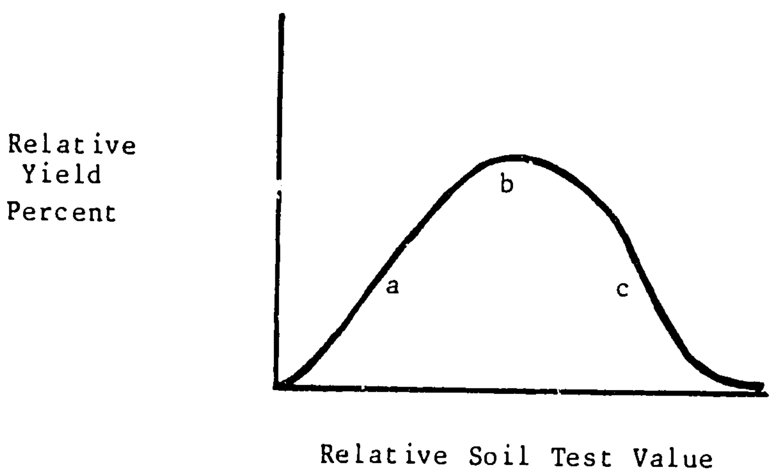
Soil Fertility

Soil Fertility Concepts - A General Statement

Numerous essential elements are required for crop production, including carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, copper, boron, zinc, manganese and molybdenum. The first three are obtained from water and the carbon dioxide of the atmosphere. The rest must be taken up from the soil by the plant's root system. Another critical element is aluminum. Although not considered essential to growth, if excessive, it is severely toxic to plants, reducing plant growth and crop yield.

Soil tests attempt to predict crop yield for a number of elements. These tests determine as nearly as possible the soil's capacity to supply the elements necessary for plant growth. Where the soil's supply is considered insufficient for a desired yield, additional amendments can be supplied to the soil increasing its "fertility", or ability to produce.

A typical soil test crop response curve follows:



The response curve has three general areas. Area "a" is the part of the curve where small inputs of nutrients result in increasingly greater production, i.e. the output:input ratio is favorable. Area "b" is a relative plateau where increasing inputs do not result in increasing yields and the output:input ratio is poor since yield can be maximized at a lessor input rate. Area "c" represents the portion of the curve where additional nutrients actually reduce yield because of excessive or toxic concentrations. This is the situation with aluminum in many unlimed soils of the tropics. A few simple equations help to explain the relationship between the soil and plant nutrients. The general relationship between elements in the soil and plants may be seen in the following where E represents an element used in plant growth.

$$\text{Soil Solid phase}_{(E)} \rightleftharpoons \text{Soil Solution phase}_{(E)} \rightleftharpoons \text{Plant Root}_{(E)} \rightleftharpoons \text{Plant Top}_{(E)}$$

As the above indicates, an element is taken in by plant roots and moved to the plant top as a soluble element dissolved in the soil solution. Elements are generally considered to be available when they are in the solution phase of the soil. In many instances an element is unavailable to the plant because it is not in a form the plant can use, that is, not in solution. Another equation helps to explain the soil fertility-plant nutrition relationship. Again, E represents an element necessary for plant growth.

$$\text{Unavailable}_{(E)} \rightleftharpoons \text{Available}_{(E)}$$

This simple equation shows the equilibrium in the soil which determines if the nutrient can be used by a plant. This equilibrium is controlled by the soil environment - soil pH, microorganisms, oxygen, water, temperature.

Soil Acidity and Liming

Soil pH is a term used to delineate the relative acidity or alkalinity of soils. It is important because soil pH affects the availability of most nutrients. The soil pH scale follows:

1 2 3 4 5 6 7 8 9 10 11 12 13 14

More Acid — More Alkaline or basic

Early in history, man learned to cultivate high base soils (soils high in calcium, magnesium and potassium and low in aluminum) because they are naturally more productive. Most cultivated soils of the tropics are not acid (Sanchez, 1976), although the majority of soils of the humid tropics are acid. Soils of tropical America are more acid than those of tropical Africa and Asia.

Liming of the acid soils has been a long-standing agronomic practice. For a long time, the practice involved adding sufficient lime to raise the soil pH to 7 (neutrality). However, in the early 1950s, soil chemists showed that exchangeable aluminum, so toxic to plants, was the predominate element in acid mineral soils, as contrasted to organic soils with a pH of 5 or less (Coleman and Thomas, 1967). Exchangeable elements such as calcium, magnesium, and potassium are positively charged and are held in the soil by negatively charged sites. Strongly acid soils (pH less than 5.0) favor aluminum availability to plants, whereas above pH 5.5, calcium, magnesium and potassium prevail.

High soil solution aluminum, the available form for plants, causes reduced plant growth because aluminum is toxic to plants. Evans and Kamprath (1970) found that an exchangeable aluminum saturation of 60 percent (% of negative sites with aluminum) was required before a large amount of aluminum was present in the soil solution. Work in Guyana showed that an aluminum saturation of less than 60 percent resulted in less than one ppm -- one part per million -- in the soil solution (Cate and Sukhai, 1964). Increasing fertilizer results in an increase of aluminum in the soil solution (Fried and Peech, 1946). Therefore, use of high amounts of feritlizer could increase aluminum toxicity if the soil is sufficiently acid. Available aluminum in the soil solution decreases with increasing organic matter since aluminum forms very strong complexes with organic matter making it unavailable to plants.

Research by Kamprath (1970) showed that elimination of all the exchangeable aluminum was not necessary to obtain maximum yield in field and greenhouse studies. Maximum yields of corn, soybeans and cotton were achieved with aluminum saturation values of less than 45, 20 and 10 percent respectively where soil pH was low. Growth of sugarcane was severely depressed on a soil with an exchangeable aluminum saturation of 70 percent. Addition of lime to reduce the aluminum saturation to 30 percent resulted in a four-fold increase in sugarcane growth (Abruna and Vincente-Chandler, 1967).

Finding the Correct Lime Level

The work cited above, plus other work, has shown that lime should be added to reduce the toxic levels of aluminum. This results in a much lower soil pH and the use of much less lime than the traditional approach of liming to neutrality. Liming beyond this point has resulted in reduced yields on soils of the tropics due to deficiencies of manganese, zinc and/or iron. Like aluminum, manganese becomes available as the soil becomes more acid (Black, 1967). Some soils are low in aluminum but high in manganese. In either case, liming will reduce the availability of manganese however since manganese is an essential element, liming must not be so high as to make the element unavailable and reduce the soils productivity.

Our liming philosophy, therefore, should be to add sufficient lime to decrease the availability of aluminum without limiting maganese to the point of deficiency particularly in low manganese soils. According to Sanchez (1976) the factors to be considered are (1) the amount of lime needed to decrease the percent of aluminum saturation to a level at which the particular crop and variety will grow well, (2) the quality of lime and (3) the placement method. Kamprath (1970) suggests that lime recommendations be based on the amount of exchangable aluminum and that lime rates be calculated by multiplying the milliequivalents (meq) of aluminum by 1.5, to find the meq of calcium needed as lime. Lime rates calculated by this method neutralizes 85-90 percent of the exchangeeable aluminum in soils with two to seven percent organic matter, the majority of soils. Sanchez (1976) states that this method has been successfully used in Brazil since 1965 and is employed in most of the Americas. The application of this formula has reduced rates of liming substantially, particularly in acid, highly leached soils low in cation exchange capacity, a term for the amount of negatively charged sites in the soil. In most cases where one to three meq of exchangeable aluminum is present, lime applications are now on the order of 1.6 - 5 tons per hectare. In the past, rates of 10 - 30 tons per hectare were frequently used with mixed results.

Different crops tolerate different levels of aluminum. Crops such as cotton, sorghum and alfalfa are susceptible to levels of ten to twenty percent aluminum saturation, therefore, liming should be aimed at zero aluminum for these crops. Corn is sensitive to 40 to 60 percent aluminum saturation, therefore, 20 to 30 percent aluminum saturation could be more economical for corn. Other crops such as rice and cowpeas, are more tolerant than corn. Coffee, pineapple, and some pasture species seldom respond to lime, even in soils with high aluminum saturation.

Sources of lime are difficult to find in the tropics. If possible, lime should contain both calcium and magnesium. The coarseness of the lime also affects its usefulness. Coarse lime, that which does not pass through a 20 mesh sieve, will have very little reactivity; what does not pass through a 60 mesh sieve will react very slowly. Fine lime, that which passes a 100 mesh sieve, will react quickly. Generally, good grade of fineness is more than 60 mesh; a better grade is 100 mesh. Lime is commonly mixed in the top six to eight inches of soil where possible. In Puerto Rico, Abruna et al. (1964), observed no differences in pasture yields between surface-applied and soil-incorporated lime applications.

When very acid, leached soils are limed to pH 5.5, most of the root development occurs in the top soil. The highly toxic aluminum in the subsoil prevents deeper root development. In such cases, plants suffer from water stress during short term droughts even though the subsoil is still moist. Gonzales and Kamprath (1973), as cited by Sanchez (1976) incorporated lime at 0 to 6 inches and 0 to 12 inches in a Brazilian soil having excellent granular structure which permits deep incorporation with a roto-tiller. Deep placement of lime resulted in deeper root development, diminished water stress during drought and increased corn yield of 20 to 25%.

Nitrogen

Nitrogen is very crucial to crop production and the availability of protein to tropical people. Acid soils contribute to that problem largely because nitrogen fixation by leguminous plants is reduced by soil acidity. In nitrogen fixation, the nitrogen of the atmosphere is made available to plants. Next to water, nitrogen is the most limiting factor in crop production in the tropics. It is necessary for protein synthesis and production. Plant-available nitrogen is derived from organic matter, leguminous nitrogen fixation, fertilizers and animal manure. The main source of nitrogen in the tropics is organic matter decomposition. Therefore, practices which maintain organic matter in the soil are essential. Organic matter not only provides nitrogen, but it improves the soil's physical condition and water-holding capacity, increasing water to plants and decreasing the soil temperature.

Nitrogen Supply Process

Nature has provided the nitrogen for crop production since the beginning of time through natural processes. However, seldom has it provided an abundance of nitrogen for long and sustained periods of crop production on the same land area. Moreover, natural supply processes at their best have seldom provided enough plant-available nitrogen to achieve the level of food and fiber production needed to meet the demands of present day crop production. Bartholomew (1972), states the natural supply processes include (1) mineralization of nitrogen from soil organic matter and from crop residues and the reverse process of immobilization in the decomposition of plant and animal debris and soil organic matter; (2) fixation of nitrogen from the atmosphere, largely though biological processes; (3) addition of nitrogen through rain and other forms of precipitation.

The nitrogen in soil organic matter is an important source of nitrogen for crop production. Soil nitrogen, however, is not inexhaustible. It declines in quantity in the soil as it is used by crops grown on the land, harvested or removed from the land. Nitrogen in soil is largely organic, replenished by periodic additions of fresh plant or animal residues.

Under normal conditions, nitrogen is added to the organic portion of the soil each year through crop residues (immobilization), but it is unavailable in this form to plant. Through biological decomposition, organic nitrogen in the soil is continuously converted to the inorganic form (mineralization) which is available to plants. Under any sustained system of crop and soil management, these two processes tend to balance so that mineralization equals immobilization (Bartholomew and Kirkhan, 1960). When this balance is attained, the system is considered to be in equilibrium.

The implications and consequences of an equilibrium in the soil's organic nitrogen need to be emphasized. At equilibrium, the amount added to the supply of organic nitrogen is essentially balanced by a like amount of decomposition. The total quantity of soil nitrogen remains unchanged and the net amount supplied to a crop is zero (Bartholomew, 1972). Under periods of virgin or noncultivated conditions, such as in a forest, certain soils tend to build up organic matter, accumulating as much as 10,000 kg per hectare of nitrogen. During the first years of cultivation, these soils may supply as much as 400 kg per hectare of available nitrogen per year to crops (Schreiner and Brown, 1938). As cultivation continues and the organic nitrogen declines, the quantity of nitrogen available to the crops also declines. After long periods of cultivation, the soil's organic matter becomes exhausted since it is the major source of available nitrogen. Unless legumes are grown or the soil fertilized with nitrogen, annual available nitrogen is depleted, except for the limited amount from rainwater and nonsymbiotic nitrogen fixation.

Many of the major land areas of the tropics have now been cropped for extended periods and the organic matter stored under virgin conditions has been dissipated. With little or no use of nitrogen fertilizer, tropical crop yields reflect the paucity of the natural nitrogen supply from rainwater and nonsymbiotic nitrogen fixation.

Yields of corn of 600-1200 kg per hectare and of wheat of 400-800 kg per hectare require a nitrogen supply only a little larger than could be expected from rain and from nonsymbiotic fixation. Yields this poor remove no more than 15 kg per hectare of nitrogen from the land in the harvested grain products. Such minimal yields can be sustained for a long period of time without nitrogen amendments but do little to sustain the protein needs of animals or humans. Low productivity due to nitrogen deficiency was demonstrated in Tanzania by Reinhard Woytek (personal communication, 1985) of the German Agency of Technical Cooperation (GTZ). He described a recent experiment where no input corn yielded 0.3 ton/ha while corn receiving manure ranged from 1.5 to 2.5 ton/ha. Manure increased the protein in the grain from 27 kg/ha to 135-225 kg/ha. Nitrogen uptake in the grain would have increased from 4.3 kg/ha to 22-36 kg/ha, an increase of five to nine fold.

Inclusion of legumes in the rotation, either as a primary food crop or as a green manure, can increase the nitrogen supply in the soil-plant system substantially. The increased crop protein level could meet the primary malnutrition problem of the tropics.

Biological Nitrogen Fixation

Despite the great use of chemical fertilizer today, biological nitrogen fixation processes, not chemical fertilizers, have been responsible for providing most of the nitrogen currently used by plants and animals (Bartholomew, 1970).

According to reviews by Henzell and Norris (1962) and Jones (1972), nitrogen fixing bacteria or Rhizobium account for 100 to 300 kilograms of nitrogen per hectare a year. Whitney (1975), in tropical research reports an annual range of 47 to 905 kilograms of nitrogen per hectare for pure stands of an improved variety of Leucaena leucocephala, a leguminous tree.

Legumes increase nitrogen in a cropping system several fold (15 kg/ha vs several hundred kg). Jones (1972) found that differences among adapted species within a specific environment were closely related to dry matter production (total growth). This suggests that there is little difference in the capacity of legumes to fix nitrogen as long as they are adapted to the environment. Factors affecting dry matter production, such as moisture or nutrient stress, solar radiation, diseases, and other factors will determine nitrogen fixation.

Pastures and meadows make up the greatest portion of the land which is managed for food consumption, therefore, potential increases in food are large if this segment of tropical production could be increased. Another important factor to consider is that production from pastures and meadows results in increased meat and milk, both high in quality proteins for local consumption.

Some individuals consider cattle to be a very inefficient source of protein in the food chain for humans. This is true when animals and humans compete for grain. It is not true when cattle convert forage from pasture and meadowlands into meat and milk. The determining factor will be how much and what kind of land is available for cultivation.

There is some evidence that beef production will increase two to fourfold (Jones, 1972) due to establishment of grass-legume mixtures. Sanchez (1976) cites Shaw and Mannetje (1970) who introduced a legume, Stylosanthes humilis into a Queensland, Australia, pasture and followed beef production for seven years. The following table summarizes the results:

Beef Production Systems in the Tropics

Treatment	Beef kg/ha
Grass alone	24
Grass & fertilization[1]	62
Grass & legume	93
Grass & legume & fertilizer[1]	148

[1] Annual application 10 kg P/ha as 0-20-0 and 40 kg K/ha plus Mo.

It is interesting to note that the grass-legume treatment produced more beef than did the fertilizer treatment. The grass-legume mixture plus fertilizer more than doubled the beef produced by grass alone plus fertilizer, demonstrating the effect of adding nitrogen to the system via the legume.

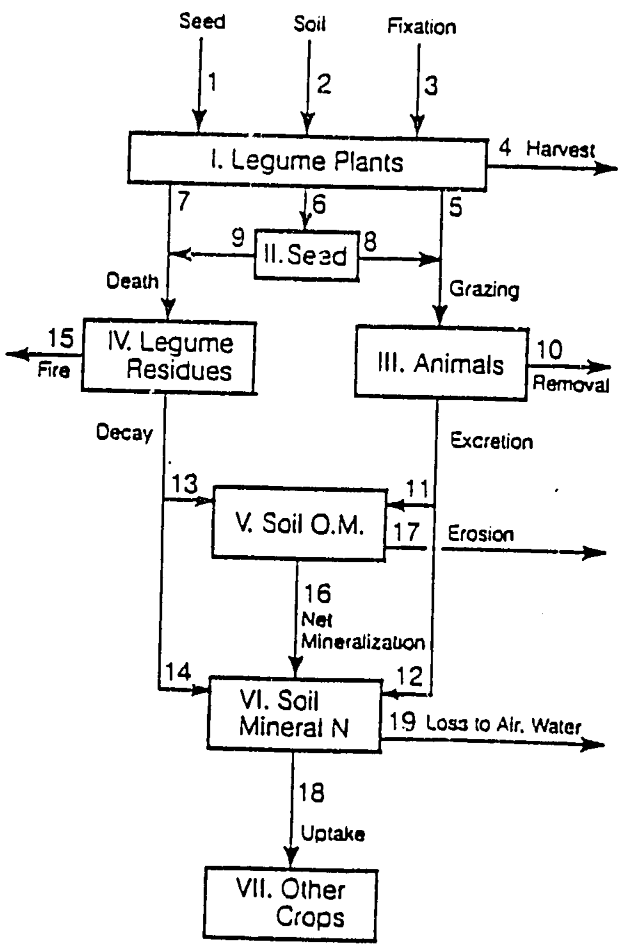
Another plant, a fern, Azolla, which grows in association with rice, the major crop of Asia. Azolla does not fix nitrogen itself, however, grows in symbiotic association with blue green algae Anabaena azollae

(Clark, 1980). About ten percent of China's rice (3.2 million acres) are grown with Azolla. He states that yields of rice of six tons per acre have been reported along with 60 tons of Azolla. Rice with conventional fertilizers yields about four tons per acre. Preliminary experiments indicate that Azolla will produce 50 to 180 pounds of nitrogen per acre, making it highly attractive as a natural nitrogen source.

Field beans, Phaseolus vulgaris, a staple in many Latin American countries, appear to fix little nitrogen (Sanchez, 1976). This is attributed to poor nodulation characteristics which may be due to low phosphorus or high aluminum which inhibit Rhizobium activity. When these legumes are grown, they contribute nitrogen to the system in an organic form, becoming part of the organic matter and eventually available via mineralization or the breakdown of complex nitrogen compounds into simpler nitrogen compounds.

In achieving nitrogen self-sufficiency, we need to consider not just legume nitrogen fixation, but the transfer of nitrogen to other crops from legumes, Henzell and Vallis (1975) reviewed this subject extensively and present the hypothetical flow of nitrogen through the system in Figure 1.

Figure 1: Pathways for Flow of N From Legumes to Other Crops.



Nitrogen in Legume Plants

The amount of N taken up by leguminous plants varies according to species, effectiveness of the plant-Rhizobium symbiosis, environmental conditions, soil fertility, and management. Crops such as guar, cowpea, mung bean, soybean, and groundnut commonly contain 80 to 250 kilograms of N per hectare (Donald et al., 1963; Norman, 1966; Weber, 1966; Firth et al., 1973; Musa and Burhan, 1974), though a range of 30 to 60 kilograms of N per hectare has been reported for pulse crops in India (Mehta, 1970).

The amount of N taken up by tropical pasture legumes is similar to that of crop legumes. Henzell (1968) estimated that the average growth of pasture legumes in tropical and sub-tropical Australia yields 40 to 210 kilograms of N per hectare each year, while very good growth produces up to 340 kilograms of N per hectare. Measurements in other tropical countries cover a similar range (Jones, 1942; Moore, 1962; Whitney et al., 1967: Keya, 1974). Most of these measurements are for legumes under cutting or lenient grazing. The amounts under heavy grazing may be nearer the lower end of the range.

The proportion of legume N derived from symbiotic fixation varies. It is often about 50 percent in fertile soils (Vincent, 1965), but is likely to be higher in N-deficient soils and lower where substantial amounts of N fertilizer are used (Vincent, 1965; Weber, 1966). In grass-legume mixtures, the proportion will probably be 80 percent to 90 percent or more, because the grass usually takes up most of the available soil N (Walker et al., 1956; Vallis et al., 1967; Henzell, 1968).

Because of the difficulty of harvesting roots and nodules, little data is available on the distribution of N in legumes on a whole-plant basis. Nevertheless, it appears that 70 percent or more of the plant N is translocated to the above-ground portions (Russell, 1961; Whiteman, 1971; Musa and Burhan, 1974).

Where grain or forage is harvested, 60 percent to 90 percent of the legume N may be removed from the land, the percentage being greater when the plant tops are harvested for green forage or hay, and when the whole plant is removed for threshing.

It is more difficult to define the pathways for N in pasture legumes. pasture will usually be grazed right up to the time the land is plowed for cropping. At any instant, 70 percent to 80 percent of the N will be in the plant tops, but only part of this can be grazed. With maximum efficiency, domestic livestock may remove up to 90 percent of the herbage N that could be harvested by mechanical means (Henzell and Ross, 1973).

Okorie et al. (1965) estimated that, under intensive rotational grazing, cattle utilized 45 percent to 74 percent of the available fodder in a mixture composed predominantly of *Cynodon plectostachyus* and *Centrosema pubescens*.

With sheep and cattle, the proportion of dietary N removed in meat, milk or wool depends on the productivity of the animal and the quality of its feed. Henzell and Ross (1973) estimated that the following percentages of N were retained in relatively productive pastoral systems: sheep for wool, 5 percent to 13 percent; milk cattle, 13 percent to 28 percent; beef cattle, 4 percent to 10 percent. In practice, the range will be from a negative percentage of ingested N (for animals in negative N balance on poor feed), to about 28 percent. The proportion will usually be less than 10 percent when ruminants of average productivity graze on tropical pasture legumes or on the stubble of tropical legume crops. In absolute terms, 2.4 to 2.6 kilograms of N in 1,000 kilograms of cow's milk.

The other part is the N consumed on the land, but excreted elsewhere. The loss of N must be significant when animals are shut away at night, and may be important even when they move off the land merely for water or to camp. Although no one has adequately quantified this process as far as we are aware, the distribution of excreta on pastures has been measured. Hilder (1966) recorded a considerable concentration of N on sheep camps: about one-third of the total fecal output was found on less than 5 percent of the area of most grazed paddocks. Clearly, the fraction of ingested N removed will depend on the amount of time spent off the land. More fecal N than urinary N may be removed because of the faster rate of passage of urinary N.

Even when grazing animals are confined to cropping land, the N in their excreta is distributed very unevenly. Only about half the surface of highly productive pasture land grazed by cattle is affected by dung or urine in any one year, with a high stocking rate and complete return (Wilkinson and Lowrey, 1973). The proportion of land influenced by excreted N is likely to be much smaller when grazing is for only part of the year or at a lighter stocking rate than the cow-and calf per acre (2.47 per hectare) assumed by Wilkinson and Lowrey (1973).

The partition of N between feces and urine is related to the percentage of nitrogen in the diet. It is certainly not a constant, as some have implied. The excretion will be predominantly in the feces when animals are consuming feeds of 0.4 percent to 0.6 percent nitrogen with no apparent N digestibility. On the other hand, animals on a diet containing 3.5 percent nitrogen excrete about three-fourths of the N in urine (Henzell and Ross, 1973).

The preceding sections show that the amounts of N returned to the soil in legume residues will vary widely, depending on the yield of the legume and whether it is utilized for grain, forage, grazing or green manure.

Loss of N from residues by fire or erosion will not be considered in detail. if dry residues are burned, more than 90 percent of their N will probably be lost. Loss by erosion will usually be negligible.

The main interest is in the proportions of residue N that are mineralized or incorporated into soil organic matter. The mineralization of N in plant residues has been studied extensively (Bartholomew, 1965). Only the main quantitative aspects will be discussed here. The proportion of N released during decomposition of the residues is governed by the chemical composition of the residues -- especially the N content, the manner in which residues are returned to the soil, and environmental conditions.

A predictable consequence of the variable N concentration in different legume residues is that they will contribute varying amounts of N to the crops that follow. This is demonstrated in Figure 2 (Henzell and Vallis, unpublished data). Most of the difference between residues can be attributed to their N percentages (Figure 3). Materials containing less than about 1.5 percent N do not mineralize any of this in the short term. The exceptionally low availability of N in Desmodium intortum leaves is thought to be caused by a reaction between proteins and tannin-like polyphenols that accumulate in this species (Vallis and Jones, 1973).

A notable feature of N mineralization in plant residues is that, after a few weeks, the rate of mineralization is quite slow, regardless of the initial composition of the residues (Figure 2). Apparently, it is not the plant proteins that are resistant to decay, but the microbially produced organic N, which becomes stabilized by reactions with aromatic polyphenols of microbial or plant origin (Bartholomew, 1965), or with montmorillonite (Sorensen, 1972; 1975). This has important implications in practice. Nitrogen in crop residues that is not mineralized during the first season becomes available only very slowly to subsequent crops, usually at less than 5 percent per year, and certainly at less than 10 percent per year. Although a single addition of crop residues will have a negligible effect on the N supply after the first crop, the effect of repeated additions over many years may be measurable in two or three successive crops (Bartholomew, 1965).

Placement of residues on the soil surface rather than burying or mixing them in the soil results generally in slower decomposition and slower mineralization or immobilization of N (Parker et al., 1957; Parker, 1962; Moore, 1974). Environmental conditions have little effect on the

Figure 2: Uptake of N by Rhodes Grass From Un-Ground Legume Residues Mixed With Soil In Pots.

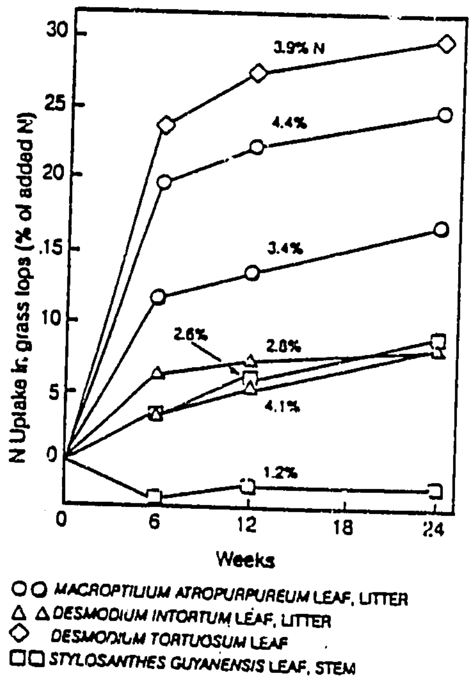
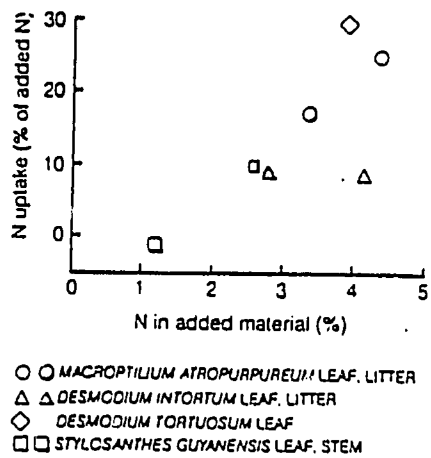


Figure 3: The Relationship Between N Uptake by Rhodes Grass From Legume Residues Mixed With Soil and the N Concentration of the Residues.



final degree of mineralization or immobilization of N during aerobic decomposition of residues; only the rates of these processes are substantially affected (Bartholomew, 1965). However, the delay caused when material dries on the soil surface should always be noted.

It has already been stressed that the N in decaying legume residues, after the initial flush of mineralization, is made available quite slowly. Nitrogen in ruminant feces is considered to belong immediately to the N in soil organic matter. Fecal N is primarily bacterial material; the remainder is undigested plant N or N of animal origin. Nitrogen in feces is mineralized more slowly than N in plant meterial with a similar N concentration (Barrow, 1961).

At most, 60 percent (Bartholomew, 1965) of the N in legume residues is likely to be mineralized in time for a following crop. The remainder finishes up in soil organic matter. After the first year, its availability is generally less than 10 percent per year.

Soil Fertility in Semi-Arid Areas

Plant-available inorganic nitrogen in most tropical areas shows a marked seasonal fluctuation (Sanchez, 1976). This is characterized by a slow nitrate (available form to plants) build-up during dry season. There is a large, but short-lived, increase at the beginning of the rainy season, and a rapid decrease during the rest of the rainy season due to leaching.

Nitrogen deficiency is widespread in semi-arid areas, and soil management to provide adequate nitrogen for high yields is of nearly universal concern. Since soils are often deficient, nitrogen must be added to the system to sustain productivity. Manure and composts are one way to accomplish this, but legumes should also be considered if they fit well into the economic and social pattern of the region's agriculture and if there is sufficient high-nitrogen residue after harvest.

In areas where water is scarce, green-manure crops must be carefully managed or they will deplete soil moisture to a very low level, resulting in reduced yield for the main crop. The nitrogen-water relationships must be taken into account in any cropping system which would use a green-manure to provide the nitrogen.

If water deficits limit early growth, or are distributed throughout the season, canopy development and transpiration may be unaffected by nitrogen level, and yield reduction from nitrogen is improbable. Also, if inter-row soil surfaces are wetted by frequent rains during canopy development, evapotranspiration is less affected by the additional cover caused by high nitrogen.

Since the best nitrogen levels must be determined based on probability of rainfall, the wider optimum range is of considerable value.

In the short term, crop residue management -- and therefore tillage -- can have a major impact on nitrogen availability. Decomposition of highly carbonaceous residues competes with the crop for mineralized nitrogen in the soil. If the residue is incorporated into the soil well ahead of planting, decomposition will be largely completed, and the nitrogen will be released and become available to the crop.

But if residues remain on the surface up to planting time, and are not in full contact with the soil, decomposition continues after planting. Whether the resulting cutback in available nitrogen is great enough to reduce yields depends on the amount of residue remaining, its relative content of carbon and nitrogen, and the weather conditions following planting.

Since the effects of residue depend on the rate and timing of decomposition, variable results can be expected where conditions differ. For example, higher soil temperatures in warmer regions may accelerate decomposition before planting, leaving the nitrogen supply to the crop unaffected. If appreciable residues are present at planting, higher soil temperatures could speed decomposition and enhance the competition with the crop for nitrogen.

Despite the complexity, the impact of proposed residue management practices on the nitrogen supply to the crop always should be considered. And if anitrogen source is applied, the timing sould be compatible with both residue maintenacne and the nitrogen requirements of the crop.

Nitrogen Fixation in Legumes in East Africa

Keya (1977) reviewed the role of legumes in East African agriculture. Cropping systems involving monoculture of non-nodulated plants resulted in a decline in yields and depletion of certain soil nutrients. This decrease in productivity was alleviated in the past by shifting cultivation, and more recently by the use of inorganic fertilizers. Since the population in East Africa has been increasing by approximately 3 percent per year during the last decade, the resulting pressure on the land has made shifting cultivation untenable. The price of synthetic fertilizer has risen considerably during the last 15 years.

In this context, it is important to find out to what extent biologically fixed nitrogen can be supplied to crops. Jones (1942) assessed the role of a leguminous cover crop such as Glycine wightii in building up total soil N in Kenya. The experiments ran for nine years and compared soil from a legume-planted plot with soil from an adjoining cultivated plot. At the end of the study, the legume had increased the N content of the Kikuyu friable loam soil by 180 kilograms per hectare per year. Total soil N was increased from 0.206 percent to 0.292 percent, a gain of abount 40 percent. This is equivalent to an accumulation of about 1,681 kilograms of N per hectare within nine years, more than half occurring in the first four years. However, these values were based entirely on an ungrazed legume cover crop. In practice, the crop is normally havested or grazed as a source of livestock feed.

At Molo, Kenya, Morrison (1966) found that Louisiana white clover (Trifolium repens) with cocksfoot increased the pasture yield in the second year as much as an application of 244 kilograms of N per hectare as calcium ammonium nitrate (20.5 percent N). In Kitale, Kenya, the inclusion of Desmodium uncinatum with Nadi Setaria increased the yield by an amount equivalent to the application of 163 kilograms of N per hectare as ammonium sulphate nitrate (26 percent N Suttle, 1968).

Souza (1968), based at kitale but working in different ecological zones of Kenya, showed that lucerne, a legume which did not nodulate naturally, fixed the equivalent of about 56 kilograms of N in 120 days when inoculated. In field trials, he also showed that profusely nodulated Phaseolus vulgaris bean fixed adequate nitrogen to meeet its nutritional requirements. Keya (1977) estimates that inoculated and nodulated beans grown at the University of Nairobi fixed 55 kilograms of N per hectare in 120 days, using non-nodulated beans to calculate nitrogen uptake from the soil.

On hillsand soils at Ukiriguru, in western Tanzania, five forage legume-grass mixtures were compared with four levels of fertilizer nitrogen applied to Cenchrus ciliaris pasture (Walker, 1968). Macroptilium atropurpureus and Stylosanthes guyanensis in the grass-legume mixture increased herbage yield much more than an addition of 106 kilograms of N per hectare as nitrochalk to pure grass.

On coastal, sandy soils of mainland Tanzania, Anderson (1968) reported that overseeding of the palatable legumes with grass improved the protein production of the indigenous sward. Adding lucerne to pastures increased the nitrogen status of a volcanic soil at Njoro, Kenya, without the use of nitrogenous fertilizers (Thomas, 1972). Thairu (1972) and Keya et al. (1971) showed that increases in quantity and quality of herbage resulting from oversowing the Desmodium spp. were substantial.

Inoculation of Legume Seeds

That nodulation of both exotic and indigenous legumes is erratic when sown without inoculation was observed as early as the 1930's by Mcdonald (1935), and has been reiterated by Morrison (1966) and others (see Keya and van Eijnatten, 1975). Extensive nodulation studies in Kenya showed that none of the introduced legumes were able to nodulate effectively without inoculation (Souza, 1968).

In northern Tanzanian soils which had previously been planted to Phaseolus vulgaris beans, no increase in yield was obtained by inoculating seed with Rhizobium (McCartney and Watson, 1966). However, inoculation is worthwhile on land where beans have not been grown or where soil pH is low (McCartney and Watson, 1966; Keya, 1977).

A series of experiments carried out between 1961 and 1965 by Weiss (1967), on Turbo and Soya estates in Kenya, showed that the use of an inoculant is essential on soil where soybeans have not been grown previously. Inoculation is essential for subterranean clover in order to achieve nitrogen fixation (Morrison, 1963). It was further emphasized by Morrison (1964) that subterranean clover, Louisiana shite clover and Kenya white clover all required different strains of rhizobia for nodulation, and that the wild strains were not fully effective. Bumpus (1957) working at Kitale, Kenya, demonstrated that, in Trifolium semipilosum, T. labidis and Medicago sativa, better results were obtained by using a good inoculant than by relying on the presence of Rhizobium in the soil. Bumpus (1957) stated that it has been well-established that there is no suitable Rhizobium in the local flora.

With Alysicarpus glumaceus, Bumpus (1957) found that the uninoculated plot yield surpassed all the inoculated treatments, and concluded that none of the commercial strains of bacteria in the "cowpea group" were as effective as those already in the soil. Nodulated plants were heavier than unnodulated ones, a difference attributed to nitrogen fixation in nodules.

Response to inoculation was further confirmed by Thomas (1972), who showed that inoculated and lime-pelleted seeds of lucerne were established quickly on volcanic ash soils at Njoro, Kenya, resulting in substantial amounts of nitrogen accumulating in the soil. This soil was about neutral in its reaction, but one of the factors limiting nodulation of lucerne in most tropical soils is low pH. Whether lime-pelleting might promote profuse nodulation in acid tropical soils has not yet been answered fully. Experiments at Kitale, conducted by Keya and van Eijnatten (1975), attempted to ascertain the role of seed pelleting and inoculation of Desmodium uncinatum under greenhouse and field conditions. In pot experiments, inoculated seedlings were vigorous, possibly because they were nodulated earlier and had more numerous and heavier nodules. However, there were no responses to inoculation and pelleting under field conditions. Keya and van Eijnatten concluded that, since D. uncinatum naturally forms effective nodules over a wide range of sites in western Kenya, inoculation and pelleting results were found for certain indigenous genera, such as Crotalaria and Dolichos spp. (Souza, 1968).

Nodule bacteria vary greatly in their ability to fix atmospheric nitrogen. Some are efficient and of great value to the plant, but the majority are only moderately effective in nitrogen fixation. It is, therefore, necessary to correct the impression that, because nodules are present on the roots, the bacteria in them must be of use to the plant. The legume-inoculum relationship has been established for temperate legumes and highly efficient nitrogen-fixing strains of rhizobia have been isolated for agricultural use. However, little is known of the tropical strains, most of which fall under the cowpea group. Field experience in East Africa casts doubt on the value of most imported inoculants used.

The implication of such findings is that, for new collections of indigenous or imported species grown under altered environments, the need to supply inoculants requires careful and urgent investigation.

The nitrogen fixation rate in a four-year-old stand of the woody legume Leucaena leucocephala (Lam.) de Wit. was estimated by Hogberg and Kvarnstrom (1982) in the field at a rather dry site in Tanzania, using an acetylene reduction technique. The amount of nitrogen fixed annually was about 110 ± 30 kilograms per hectare. The results give strong support for the use of L. leucocephala for soil enrichment in less humid areas of tropical Africa.

The Role of Trees

Use of agronomic and horticultural legumes would help provide nitrogen in semi-arid environments of the Tropics. As a strategy to provide nutrients and stability, the use of trees needs to be emphasized. This was recognized by East African farmers who still use mixed stands of tree crops, cereals, root crops and legumes, even though encouraged by Extension agents to plant single crops. Keya (1974) and Kock (1982) suggest that trees may be the key to successful farming systems in the Tropics.

Land use systems relying on diversity to make maximum use of an area's productive potential have to "simulate" climax vegetations to obtain maximum biological productivity. This applies especially to rainforests and savannas, which, except for pure grass savannas, naturally contain trees and bushes, whose density, composition and height depend largely on rainfall.

The contribution of natural climax vegetations to humus levels under African conditions has been summarized by Sanchez (1976), using data of Greenland. Rainforests produce up to six times as much organic matter as savannas, but their decomposition rates are only 1.5 times higher. Consequently, rainforest foils generally contain twice as much organic matter as savannas. Again, the net organic matter production of these depends largely on rainfall.

Although the advantages of tree integration are known by traditional farmers, and research has produced sufficient evidence of their effectiveness, "Agricultural engineers...have not taken a serious look at what can be done" (Sanchex, 1976). Except for commercial plantations, tree integration has fallen between the stools of the agriculturist, the forester and the pasturalist, each occupied with his own discipline, and each missing decisive advantages available from tree integration. Only input scarcity seems to make us aware of the superior performance of trees, whether in erosion control, in biomass and fodder prodcution, improvement of soil property, or yield performance and energy supply. Trees can be looked at as a self-contained factory that creates the conditions of its high prodcutivity, whether by soil property or ecoclimatic improvement.

The important aspect here is the choice of a noncompetitive species for the various purposes. A growing stock of documentation on suitable species exists, supplying information on suitable species for semi-arid, humid and even hydromorphic areas (IRCT, 1979; Nair, 1979, Nat. Acad. Sci., 1977; 1979).

From semi-arid to humid areas, tree integration is a characteristic of traditional, small-farmer systems serving almost all purposes. Lagemann and Heuveldop (1982) show that farmers in the humid areas of eastern Nigeria respond to higher population pressure with increasing tree densities of varying heights and species, increasingly using leaves and branches for fodder and mulch. Net income obtained from these farms exceeded that of intensive maize cropping. The same tendencies emerge from literature on traditional farming on all three continents (Anonymous, 1981; Sanchex, 1976). What may often appear to development workers as a "botanical happening over time," instead is a subtle adjustment by farmers to changing conditions, making optimum use of their own resources. With tree integration, the role of mulch on relatively undisturbed soils increases. This factor indicates possible solutions for small farmers who cannot afford to plant separate green-manure crops, but are able to use the superior biomass production performance of trees to maintain the organic matter balance in their soils.

Research has just begun to provide quantitative evidence of ecoclimatic improvement through multi-storey farming systems. An example is given by Nair (1979) in India. Multiple cropping of cocoa and coconut reduced evaporation (compared with a bare soil) by 70 percent, reduced variations in above-ground air temperatures 20 times, and helped more than double populations of bacteria and fungi in the soil.

Proof of similar soil, ecoclimate and yield improvements with tree integration in semi-arid areas, although on a lower level of productivity, is provided by French research in Senegal on Acacia albida in a millet-groundnut rotation. These improvements led to sustainable yield increases in millet of 100 percent, and/or in groundnuts by 25 percent. In semi-arid areas, nitrogen is more often the limiting factor than water. The conventional view that moisture is the most limiting factor in dry regions, and that shade is always detrimental to understorey crops, is overturned in situations where soil fertility is low and adequate amounts of mineral fertilizer cannot be added. But these are precisely the conditions which characterize small-holder production in most developing countries. Further evidence of beneficial effects can be found in Borgnettau-Verainden (1980), IRCT (1979), Nat. Acad. Sci. (1977) and Sanchez (1976).

Acacia albida is widely used on a subsistence level in the West African countries of Senegal, Upper Volta, Mali, Niger and Chad to increase the yields of sorghum, millet, and peanuts grown beneath the tree canopies (Felker, 1978). Parkia biglobosa was observed by Felker (1980) growing in sorghum fields in a 400 mm annual rainfall regime where farmers stated the Parkia also increased the yields of their crops. One thousand ha of P. juliflora has been established in the Peruvian coastal desert under partial irrigation. By providing 250 mm of irrigation the first year and 160 mm thereafter, pod production of 6-7 t ha^{-1} have been obtained from the Peruvian plantings (report of R. Peck to IDRC). In nearby Chile, 30-year-old P. tamarugo trees growing in the Atacama salt desert have produced 6,000 kg ha^{-1} of leaves and pods which is used to support a sheep-raising industry (Salinas and Sanchez, 1971). Twenty-two thousand hectares of P. tamarugo have been planted by the Chilean corporation CORFO (Zelada, 1980).

In Mexico cattle rations have been formulated from high energy, sweet, highly-palatable mesquite pods; high protein, high carotenoid and low palatability saltbush foliage; and high-energy containing cactus pads (Lorence, 1970). These three plants possess the complimentary physiological characters of high salt tolerance in saltbush, high water to dry matter conversion efficiencies of cactus, and nitrogen fixing properties of mesquite. Prosopis cineraria has been widely used in the Indian-Pakistan region on a subsistence level to increase yields of pearl millet and other forage crops grown beneath its canopy (Mann and Shankarnarayan, 1980). Acacia albida has been used in West Africa to increase yields of millet, sorghum, and peanuts (Dancette and Poulain, 1969; Charreau and Vidal, 1965; and Felker, 1978). Farmers in the 400 mm annual rainfall region of Senegal remarked to Felker (1980) that Parkia biglobosa had the same fertilizing effect as Acacia albida on millet and sorghum.

There are serious cultural constraints to development of perennial production systems since the perennial vegetation in Sahelian Africa is viewed as community-owned (Thomson, 1980). Thus, the pods or fruits from trees can be taken by anyone, even if the trees are on privately-owned land.

Similarly, people can cut branches from non-protected species of trees for fuelwood even if the landowner planted the trees for his own fuelwood use. Freely-roaming goats which eat young seedlings constitute a major problem in the establishment of perennial production systems. Control of the movement of goats is probably an insoluble cultural problem and thus goat-proof devices for protection of young seedlings will have to be devised.

Political constraints for the development of these technologies stem from politicians' and bureaucrats' unfamiliarity with use of these perennial crops. Although the superior performance of trees is obvious to any observer going through a barren landscape in the dry season, development projects often are not geared to using trees as living fences, as bunds for erosion control, or as planned crop mixtures. The same situation applies in the case of local researchers, who generally lack the capability to provide seed collections of suitable species and site-specific agronomic recommendations. Again, monodisciplinary training and organization is often to blame for this circumstance. Tree integration would convert densely populated, barren landscapes, vulnerable to all forms of degradation, into "healthy," park landscapes with a ligh tree and bush cover.

Conclusions and Recommendations

Biologically produced nitrogen is becoming increasingly important as synthetic nitrogen escalates in price.

In many areas, nitrogen is readily available on the farm in manure and plant materials. If managed properly, these materials could provide sufficient nitrogen without the expense of chemical nitrogen. Traditional farming methods in many areas of the tropics have reduced the soil organic matter content to low levels, resulting in a nitrogen supply which does not support high yields.

Legumes offer a biological approach to increase substantially the nitrogen available to tropical soils, and thereby lift the yield ceiling now restricting crop production. The nitrogen-water-yield relationships will dictate the nitrogen management strategy. For instance, in water-poor areas, green-manure crops can reduce yields by depleting available water. In these areas, mixed cropping and the use of legume trees offer a superior production system which uses resources efficiently and raises the yield plateau. It is important that legume trees be integrated into such a system, since they are locally available and provide stability to tropical production.

The amount of biological nitrogen provided by manures, plant materials and legumes could far exceed that which is presently bought as chemical nitrogen, and result in substantial yield increases at lower cost while improving the soil's water-holding capacity.

Leaching is not a serious problem with organic nitrogen from legumes or animal waste since these complex organic materials are not subject to leaching like the more soluble inorganic fertilizers. This suggests a greater efficiency for organic forms in high rainfall areas. In some cases nitrogen addition alone will not increase productivity substantially as other elements may be deficient or toxic. Such is the case with acid soils. Lime will promote legume establishment and growth by reducing aluminum availability and increasing the availability of phosphorus. Phosphorus deficiency is a serious problem in many tropical soils and must be considered in the fertility regime.

Phosphorus

Following water and nitrogen, phosphorus is probably the most limiting nutrient in the tropics. This is particularly true in the acid soils of the humid tropics since the high aluminum and iron concentrations render phosphorus unavailable to plants. The term used to denote this is phosphorus fixation. When phosphorus is added as soluble monocalcium phosphate ($Ca(H_2\text{-}PO_4)_2$) the soil pH is reduced to 1 to 1.5 (very acid). The acid dissolves aluminum, iron, potassium and magnesium compounds and unsoluble phosphates of iron and aluminum are formed. The higher the phosphorus-fixing capacity of the soil (Sanchez, 1976), the higher the content of iron and aluminum oxides. Higher exchangeable aluminum also increases the soil's phosphorus fixation ability. Because of the fixation process, higher rates of phosphorus must be added to achieve the same level of plant-available phosphorus compared to a soil which does not fix phosphorus. The amount of phosphorus added to a soil to get 0.2 ppm phosphorus (adequate level) in the soil solution can vary from 20 to 30 pounds per acre to as much as 1500 pounds per acre. A general recommendation for corn and rice in Latin America is 100 to 150 of kg

P_2O_5 per hectare for corn and from 0 to 60 kg for upland rice. In many cases soils respond only slightly to phosphorus unless they are first limed (CIAT, 1971). In an experiment, limed corn plots showed a marked response to 50 kg P_2O_5 per hectare with a yield increase from 0.8 to 3.2 tons per hectare. In limed plots rice did not respond to phosphorus.

Management of Phosphorus Fertilizer

Phosphorus responses are common in many tropical soils. Well calibrated soil test procedures can identify the soils with a high probability of phosphorus response. In soils with high phosphorus fixation capacity economically sound phosphorus management involves several approaches (Sanchez, 1976). Two general approaches are used to deal with high phosphorus fixing soils: one is to apply small to moderate rates in bands near the plant. The other is to apply a large amount at one time saturating the soil's fixation capacity, eliminating the problem right away. However, there is a disadvantage, the very high initial investment and need for adequate financing.

Applying phosphorus fertilizers in bands is a simple practice that satisfies the phosphorus fixation capacity of a small soil volume, making the fertilizer directly available to plants. In using a system of minimal inputs, banding is very appropriate since the goal is to increase crop production with minimal inputs without changing the inherent fertility of the entire soil volume. Sanchez (1976) cites Yost (R. S. Yost, North Carolina State University, 1974) who studied banded versus broadcast applications in a high phosphorus-fixing soil of Brazil. The results showed that broadcast-incorporated applications were superior to banded applications in the first crop. Banded applications concentrated corn root development around the band. When a temporary drought struck, these plants suffered more than those of the broadcast plots, which had a more extensive root system. In time, however, the effectiveness of the banded treatments increased while the broadcast treatments decreased. Annually banded treatments began to approach the broadcast treatments as the phosphorus became mixed in the soil. Use of small amounts of rock phosphate, approximately 100-200 kg/ha in bands has been shown to be superior to concentrated super phosphate on soils in Tanzania because the rock phosphate is not fixed as rapidly (Samki, J. K., 1984 personal communication).

Sources of Phosphorus

In acid soils which fix large quantities of phosphorus, application of less soluble phosphorus sources such as rock phosphate may be more effective and economical than the slightly soluble forms. Rock phosphates are more reactive in acid soils and usually cost one-third to one-fifth as much as superphosphate per unit of phosphorus (Sanchez, 1976).

The literature on tropical agriculture is full of research indicating the desirability of high-quality rock phosphate sources over superphospate in the acid soils (Motsara and Dalta, 1971; Awan et al., 1971; Englestad, 1972) and the poor performance of low-citrate-solubility rock phosphate sources in acid soils (Alvarez et al., 1965; Viegas et al., 1970; Miranda et al., 1970). Studies at TVA by Lehr and McCellan (1972) indicate that when rock phosphate deposits (North Carolina in Tunisia) are given an index of 100, rock phosphates with a solubility index of 70 percent or greater can be recommended for direct application without testing. These are largely concentrated in North Africa, the Soviet Union and the southeastern United States.

The effects of rock phosphates of varying citrate solubility on flooded rice yields in an acid sulfate soil from Thailand was studied by Englestad et al. (1974). The initial and residual effects of the rock phosphates were highly dependent on their absolute citrate solubilities. The yield responses of the North Carolina and Florida rocks approximated those of triple superphosphate.

In the tropics high-citrate solubility deposits are limited to relatively small areas in Peru and India (Sanchez, 1976). The majority of the deposits in most tropical areas, including significant ones in Brazil, Columbia, Venezuela, Togo and India have relative solubilities lower than 40 percent. Most are unsuitable for direct applications, but their reactivity can be increased by fine grinding or by thermal alteration and fusion with silica sand, sodium or magnesium carbonates. These silicophosphates, called "Rhenenia" or thermophospates, appear to have promise for acid soils that fix large quantities of phosphorus because of the blocking effect of silicon on phosphorus fixation sites (Olson and Englestad, 1972; Fassbender and Molina, 1969).

The potential effectiveness of these cheaper forms of phosphorus in acid soils is illustrated in the following table:

Behavior of different fertilizer sources on wheat grown in Oxisols of southern Brazil

Phosphorus Source	Relative yield 5-year average
No phosphorus	100
Olinda rock phosphate[1]	179
Simple superphosphate	206
Thermophosphate	218

Source: W. J. Goedert (personal communication) as cited by Sanchez (1976).

[1]Low citrate solubility.

The low citrate solubility Olinda rock phosphate was inferior to ordinary superphosphate; but when thermally treated with silicates and carbonates to produce a thermophosphate, its effectiveness was superior to that of ordinary superphosphate. In view of the substantially lower costs of the rock phosphates and some thermophosphates, both seem desirable alternatives for soils with high fixation capacities.

An additional strategy, sometimes feasible for managing soils with high phosphorus fixation capacities, is to reduce their fixation through amendments that will block some of the fixing sites in the soil. This can be accomplished in some soils through liming or silicate additions (Sanchez, 1976).

Liming soils to pH 5.5 generally increases the availability of phosphorus by precipitating exchangeable aluminum and hydroxy aluminum. This has also been observed by Fox et al. (1964) in high fixing Hawaiian soils.

Phosphorus in manure, compost or green manure is in an organic form and will be more available over the growing season because it is slowly mineralized like nitrogen.

Applications of silicon or sand (an unessential element), usually as calcium silicate, sodium silicate or basic slag, are known to decrease phosphorus fixation and increase phosphorus uptake by crops. Suehisa et al. (1963) reported that grass yields increased from 2 to 7.6 tons per hectare and phosphorus uptake rose from 4 to 15 kg phosphorus per hectare when one ton of silicon per hectare was applied without added phosphorus.

Silicon is generally not considered to be essential to plant growth, however, positive yield responses have been achieved on highly leached soils of the tropics under intense cultivation of sugar cane or rice. Soils having low contents of soluble silicon are most likely to show response to silicon applications. Fox et al. (1967) suggested that the critical level is 0.9 ppm silicon in water extracts. Responses have been obtained on the leached soils of Hawaii, Mauritius and the rice soils in Japan, Korea and Sri Lanka.

In these rice soils, silicon applications increased yields because of a more erect leaf habit, greater tolerance against insects and disease attacks, lower uptake of iron and manganese when present in toxic concentrations in the soil, and perhaps a rise in the oxidizing power of rice roots (Okuda and Takahashi, 1965). An element with plant requirements very similar to phosphorus is sulfur. Sulfur deficiency results in a reduction of growth and protein deficiency, often resembling nitrogen deficiency.

Sulfur Deficiency

Widespread sulfur deficiencies and responses have been reported all over the tropics. McClung et al. (1959) observed sulfur responses in the Brazilian Cerrado in both savannas and recently cleared forests. In Central America, sulfur deficiencies are also widespread (Muller, 1965; Fitts, 1970). Sulfur deficiency has also been found in sub-Saharan Africa and the sandy soils of central Africa according to a review by Bolle-Joes (1964). They have been reported in Asia by Olson and Engelstad (1972) and in Australia and Hawaii by Williams (1972) and Fox et al. (1971). Sanchez (1976) summarizes sulfur deficient soils as high in allophane or oxides, low in organic matter and often sandy. Soils subject to repeated annual burning are often sulfur deficient since about 74 percent of the sulfur is volatilized (goes off as a gas) by fire. Sulfur-deficient soils occur in unpolluted, inland areas where the atmosphere is low in sulfur.

Sulfur requirements are similar to phosphorus in tropical conditions ranging from 0.1 to 0.3 percent of plant tissue. A sulfur deficiency at early growth stages may disappear later when the roots come in contact with the sulfur-bearing subsoil.

In general, small rates of sulfur (10 to 40 kg per hectare) will overcome sulfur deficiencies. Sulfur as part of either nitrogen or phosphorus manure, calcium sulfate or flowers of sulfur, is usually sufficient to take care of sulfur problems.

Potassium Deficiency

Potassium deficiencies do occur in the tropics. However, lack of potassium is not nearly as widespread as nitrogen and phosphorus deficiencies. Boyer (1982) in a review article suggests that the absolute minimum requirement of exchangeable potassium -- the amount considered to be available to the plant -- is close to 0.10 meq/100 g of soil but that this may vary between 0.07 and 0.20 meq/100 g depending on the kind of crops grown and the soils.

In Africa the most severe potassium deficiency appears in the savanna on sandy soils. In the lower Ivory Coast, potassium application resulted in very substantial yield increase with oil palm (Boyer, 1972). Potassium deficiencies have occurred in the southwestern Cameroon (Vale, 1967) in Madagascar (Vely et al., 1965) and in Brazil on sandy soils (Van Wambeke, 1970). Laudelot (1954) in the Congo (Zaire) showed that the exchangeable potassium increased from 09.067 meq/100g to 0.325 meq/100 after burning a forest. Thus clearing a forest by burning substantially increases the potassium content of soils. Busch (1958) found that the increases in bases (calcium, magnesium and potassium) persists for a number of years after burning.

When soils are potassium deficient, fertilization with moderate amounts of potash compost or manure will correct the problem. High yield crops which contain high carbohydrates such as potatoes have a higher potassium requirement than a grain crop such as wheat or rice.

Rice

Since rice culture differs from other crops due to the flooding requirement, it merits special consideration. Regardless of their original pH values, most rice soils reach a pH of 6.5 to 7.2 within a month after flooding and remain at that level until dried (Sanchez, 1976). This increase in soil pH is a result of the release of OH^- (base) ion when $Fe(OH)_3$ is reduced. Consequently, liming is of little value in flooded rice production. If low pH is a problem, flooding two to three weeks prior to transplanting may eliminate this danger.

In flooded soils, oxygen is consumed and therefore, nitrates will be lost via denitrification. Since ammonium is already reduced, it is stable in reduced (flooded) environments. Organic matter decomposition proceeds at a slower rate without oxygen, however, materials such as rice straw which has a high carbon to nitrogen ratio may mineralize more rapidly under these anaerobic conditions thus providing a source of plant-available nitrogen. Soil solution phosphorus increases upon flooding (Sanchez, 1976) explaining why additional phosphorus in flooded conditions is rarely needed.

Nitrogen uptake proceeds throughout the growth cycle of the rice plant but it is particularly critical during two physiological stages: at the beginning of tillering and at the panicle (grain head) initiation stage (Matsushima, 1965). Adequate nitrogen at tillering increases tillers which is closely correlated with yeild in short varieties. However, excessive nitrogen after maximum tillering and before panicle initiation may result in a large proportion of unproductive tillers and premature lodging in tall varieties.

Rice rarely responds to phosphorus fertilizer except in highly weathered leached soils (Sanchez and Briones, 1973). Traditional soil tests for phosphorus do a poor job in predicting the need for phosphorus under flooded conditions.

Zinc deficiency is probably the most widespread micronutrient disorder in tropical rice, occurring in parts of India, Pakistan, the Philippines and Columbia under low lowland conditions (Tanaka and Yoshida, 1970; Yoshida and Forno, 1971; CIAT, 1971; IRRI, 1971, 1972). It also occurs throughout the Cerrado of Brazil under upland conditions (De Souza and Hiroce, 1970). In lowland rice, zinc deficiency is associated with calcareous (high base) soils and is accentuated by prolonged flooding. Deficiency can be corrected by applications of 5 to 15 kilograms of zinc per hectare as the sulfate or oxide incorporated into soil before seeding (Giordano and Martvedt, 1973). An alternative is dipping the transplant seedlings in a one percent zinc oxide suspension before transplanting and mixing zinc oxide with pre-soaked rice seeds before direct seeding (Yoshida and Forno, 1971; CIAT, 1971). Yield increase of two to three tons per hectare have been achieved with one to two kilograms of zinc oxide per hectare (Brady, 1977). This again is an example of fertilizing the plant and not the soil, a much more economical and easy approach than treating the whole soil.

Potassium deficiency is rare in lowland rice as these soils are usually adequate in exchangeable potassium and receive potassium in the irrigation water when flooded. Soil tests are good for estimating potassium deficient soils (Sanchez, 1976).

Mechanisms For Regenerative Technology Development

Farming Systems Approach to Research, Development and On-Farm Testing:

A logical approach to developing and moving technology to the farm is to carefully consider the total environment into which that technology will move. The farmer is best acquainted with the resources which are internal to the farm, and often has innovative ideas on how to use these resources.

This concept of the farmer has been at variance with the research and extension community which has demonstrated and publicized methods which radically change the farmer's current systems: substituting monoculture for multiple cropping, a cash crop for several subsistence crops, expensive chemical fertilizer and pesticide inputs for traditional controls through mixed culture, and high-risk changes which require outside credit or investment compared to those traditional systems based on what the farmer could afford. There is no question about the need to make farmer systems more productive; but the active exploitation of internal resources is a much more realistic and sustainable way to make these changes -- in a regenerative farming system.

We have often blamed the extension system for not moving information to the farm. Many of the U.S. based or oriented assistance programs have assumed the eventual application of a "land-grant" system which combines research, education, and extension under one umbrella. According to Collinson (1984) of the East African CIMMYT maize program, "The fundamental problem lies not, as is commonly assumed, between researchers and extensionists. Much more serious was a failure by both research and extension to perceive farmers' problems from the farmers' own perspective. Research and extension...must look at the whole farming system." This is the way the farmer views the world, not in terms of individual crops or the specific practices which are used with them.

The farming systems approach offer a solution to this problem by involving researcher, extensionist, and farmer in one total process, working together. The Agricultural Technology Improvement Project (ATIP) in Botswana is currently implementing this approach in three locations in this dry country in Southern Africa (ATIP, 1984). Starting with an evaluation of farmer needs and local resources, the team members work with farmers to evaluate how and why crops are at their current levels of production. The recommended practices of plowing with the first rains and planting of the entire plot are evaluated in terms of the farmers' needs and knowledge of rainfall patterns and risk. Farmers are convinced that a scaled planting across several dates is less risky in this drought-prone region. Lack of adequate fertility likewise is evaluated from the farmer's point of view, and alternatives explored which would not be expensive and involve high levels of imported materials. Once these options are discussed by researcher and farmer, a program for research on farm plots is established for the coming season. Farmer and researcher work together on these plots -- and the extension specialist is an active participant as well.

The iterative process of FSR includes the following steps: (Byerlee, Harrington, and Winkelmann, 1982)

-- selection of target areas and cooperating farmers.

-- deciding together with the farmer what the major constraints are to production.

-- planning research on farm, and on the experiment station if necessary.

-- implementing the research on-farm together with the farmer, and analysis of results in terms the farmer understands, using the appropriate criteria.

-- validation of successful results on other farms.

-- broader extension of results, and identification of new constraints to production.

Interdisciplinary Team Research and Extension

The terms "interdisciplinary" or "multidisciplinary" are often heard as descriptors for the teams of several specialists who now make up groups active in research and development in the field. The tapping of expertise from a number of fields has become increasingly important as science has become more specialized, and we have concentrated research and teaching around specific subject matter areas. The theory is that several specialists working together can each contribute diagnostic skills and potential solutions to problems which are unique to each discipline, and that the sum total of this activity will be useful in solving complex challenges facing the farmer with limited resources for production of food. This can work if the specialists on the team will communicate well and focus on the many dimensions of the same problems. It will not be successful if the team is no more than a disparate group of individuals working in the same region on a number of isolated problems.

The farming systems approach provides a framework within which teams can function. If all members of the team are in touch with farmers in a region, and if there are regular meetings to share information and perspectives on how problems can be identified and potentially solved, then this type of team can make a meaningful contribution. The plant pathologist can quickly identify maize streak virus as the culprit in a yellowing field or maize in Zaire, while an agronomist and economist might puzzle for some time and debate the possibilities of nitrogen deficiency, excess water in the profile, or a variety which is genetically poor. A team of specialists is expensive, and the logistics and communications challenges are complex, yet this can be a cost-effective way to identify problems and seek efficient solutions.

Composition of an interdisciplinary team depends on the nature of production constraints, the relative importance of research versus extension of results, the size of the region under development, and the resources available. Generally a minimum team will include an agronomist and an agricultural economist with practical orientations toward farm problems and on-farm research. Other potential members of a team include plant breeder, soil scientist, plant pathologist, entomologist, weed specialist, agricultural engineer, rural sociologist, animal scientist, and communication specialist. Few teams will include all these specialists, and often a person can function as a member of several teams if that specialty is not needed on a daily basis.

The many complexities of communications within a team and of the team with farmers, the leadership models which are possible, the reward systems which help a team to function effectively, and other details on organizing and providing logistics for a team are presented in a recent paper (Sands et al. 1985) and in other papers in the same volume (Floram, 1985).

It is the involvement of all parties in this process which will guarantee success with the end products. One additional activity which is a part of the ATIP in Botswana is a "RELO: or "research-extension liaison officer". The communication between these two critical groups is important, but even that communication will not complete the cycle if the farmer is not involved. The FSR approach is currently being applied by a number of development projects in Africa and elsewhere.

Adaptation of Results From Other Regions to Africa

A key aspect of technology development and transfer or application from one location to another is assessment of the most critical constraints to production in each location, and the possible solutions to those constraints within a given economic and social milieau. It would appear efficient to take advantage of available research results and information from other parts of the world, to quickly apply solutions to the most obvious and critical problems limiting production of crops. Yet this simplistic approach often ignores the complex climatologic, biological, economic, and social factors which shape a farmer's environment and the constraints within which s/he operates (Francis, 1985).

Adaptation of recommendations from one site or region to another may be highly dependent on the specificity of solutions to major production limiting constraints. Crop hybrid or variety is only one factor in a complex production situation, but there is quantitative information on how genotype interacts with cropping system. This is presented as a model of how these questions can be evaluated. Thirty published reports on genotype by cropping systems interactions were summarized by Gomez and Gomez (1983), comparing relative varietal performance in monoculture versus intercropping. In experiments with cereals 73% of the trails had a significant correlation of results from one system to the other. Experiments with legumes showed 71% of trials with significant correlations, and only half the trials with sweet potato had significant correlations. This means that in the majority of cases, the varieties best in one system were also good in the other, but in several experiments there was no relation between the results. The conclusion is that results can be transferred from one cropping system (eg. environment) to another, but that there is a certain level of risk which must be assumed. There is no substitute for testing results before making recommendations to the farmer. These "environments" most often were side by side, comparing only the cultural system in which the varieties were grown.

Although most questions are more complex than this one on varieties, the reasoning and methodology are similar for evaluating other recommendations which might be applied in a new situation. From the agronomic and biological point of view, it is important to take into account similarities and differences in soil fertility, rainfall and temperature, and general level of technology under which varieties are to be grown in the two environments. More difficult to evaluate are the differences in cropping systems and sequencing of crops and the labor needed to grow them. Cultural factors such as taste and custom with foods are even more difficult to evaluate, and make the transfer of even crop varieties difficult from one site to another.

However, there have been monumental changes in food habits over the past 500 years. During the age of exploration and colonization by Western Europe, there was an explosion in communication from one continent to another. One side effect was the widespread transfer of domestic crops among the continents. Thus, the staple crops in Africa such as maize, cassava, dry bean, rice, potato, banana, and squash were all introduced during a short period in history. Today, maize is a more popular food in Kenya than the traditional sorghum which had been there for several centuries before maize arrived. Dry beans were tested, multiplied, and have become a staple crop in Tanzania, Zambia, and other countries in the region. These examples illustrate changes in diet, over time, which have resulted in today's mix of food crops in each country. There is still potential for change, although this often is more difficult than improving the yield of a crop already grown which will be easily accepted by farmers and by the marketplace.

One example of a crop which appears to have promise in Africa is Amaranth. This small seeded cereal which was a staple of the early American cultures in Mexico and Central America has been improved over the past ten years and is undergoing extensive research and testing in India, Thailand, Peru, Mexico, Kenya, and the U.S. Where food customs include a small-seeded cereal such as t'ef in Ethiopia, a similar seeded crop such as Amaranth could have promise. It is drought tolerant, exists in a wide range of colors and plant types, and appears to be widely adapted. There are also vegetable types which can be used as a leafy subsistance crop to supplement cereals in the diet -- these are more adapted to areas with higher rainfall. There are other crops now being studied by the international centers which have promise to relieve food shortages even under difficult growing conditions.

Differences in farm size are among the traditional indicators of resource availability, level of management, and potential for adoption of new technology. One of the principal problems in transfer of technology has been to assume that new varieties and hybrids, and the systems in which to produce them would "trickle down" or be susceptible for "down scaling" to reach farmers with limited resources. In most areas of Africa, this has not occurred. We are becoming more aware of the subtle differences in constraints and farmer needs, and that technology needs to be developed which is specific to farm systems which are limited in access to external resources.

Nevertheless, the first place to look for new technology is to that which is already successful in other locations. There are success stories in Africa. And there is a need to identify these, to study their critical elements, and to make the information available to other farmers. This underlines the importance of information -- and efficient systems which can be implemented to collect, process and screen, package, and disseminate information to those who need it most. This means visiting farmers and seeing what they are doing and finding out why -- and then getting the information into an interactive network which will help facilitate the application of this information in other similar localities. Often, farmers themselves can become agents of change. Just as the on-farm field days and the FONE network are functioning in this country, there have been projects in Guatemala and elsewhere which have used farmers to extend information to other farmers. They can be successful because of credibility in the community, first hand knowledge of production conditions and constraints, and a willingness to help others. This is one model which could be pursued.

A series of conditions which are necessary for technology transfer have been articulated by OTA in a recent report on Africa (OTA, 1984). These include:

-- technology is transferred most effectively by people-to-people actions; those who adopt technology will do this most readily if it is learned directly from others who have tried it.

-- technology needs to be adapted to the farmer and family's situation and the local biophysical and socioeconomic conditions.

-- well-qualified researchers or providers/organizers of information need to provide appropriate information to those who are doing the transfer.

-- there is a critical need for good "facilitators", whether these be local extension agents, early adopting farmers, or private or voluntary organization specialists working in the community.

-- both users and transfer agents should be involved in the choosing of technologies and in planning and implementing the transfer process.

-- everyone involved in the process needs to become a winner; the self-interests of each group needs to be identified, and these needs or reward systems considered in the design of the program.

-- each person in the process should understand the entire process, so that there is continuity and integration in the chain of events in moving technology.

-- environments where technology is tested need to be similar to those in which it will be used, to assure that the tests are valid.

-- commitment of resources to the process should be assured so that farmers will not become discouraged with "one more government project" which makes many promises but does not follow through.

-- there need to be feed-back mechanisms in the process so that recipients of technology become a part of the total process and can contribute to its efficient functioning.

Careful consideration of these factors -- in choice of technology for testing, finding sites for testing which are appropriate to an area, involving the farmer in the process -- will greatly increase the potentials for adoption of technology. The development of new varieties, practices, or other components of technology must be applied in the context of a complex farming system. The farmer needs to be a part of this process. This leads to a discussion of the "farming systems research and development process."

Research Needs

Research needs are generally discussed and a list developed which prioritizes the work that is needed. This is obviously important. However, more important may be the organizational and strategic plan to attach research problems which coincide with national goals and priorities. It is very important that research be task oriented, multidisciplinary in nature or holistic and not reductionist in approach whatever the research agenda is. If farming systems research is necessary, which would seem to be the case, then it is imperative that research be organized in this fashion and that evaluation of researchers to be done on this basis. Resources are too limited to allow individuals to go off on their own without regard to national or regional goals.

Another change that is needed is to make farmers part of the research process. Farmers have gained much experience about farming systems and their experience and knowledge is too valuable a resource to disregard.

Research in developing countries should be of the type where the payoff is quick (1-5 years) and therefore by nature should be applied in nature. Basic research should be left to countries and the large international research centers that have the resources to tackle these projects.

In the preceding sections of this paper we have basically discussed theoretical material and real life data which impinges upon the production of food and fiber in developing countries. We have discussed nutrient management and cultural practices which affect the production of plants and animals and ultimately food which will be consumed by humans. In a sense, then, we have set the stage for looking at what research needs should be or ought to be in the near future with respect to food production where resources are limited. Nutrient management is a very critical issue in many of the developing countries. From previous data it is clear that if nitrogen management is not dealt with, management of many of the other parts of the farming system will not produce the results that are desired.

Since nitrogen fixation package management is so crucial it is imperative that research be initiated on locally available legumes and associated bacterial species which is the nitrogen fixation package. Nitrogen in most tropical soils is quite low and therefore the only pragmatic way to get nitrogen into many of these systems is via legumes. Part of this legume package should include trees -- legume trees which can add forage, green manure and also be a source of fuel wood where this is a problem.

Agroforestry research is rather new and this needs to be a significant part of the legume package in regard to nitrogen utilization in these areas. In semi-arid areas it will be very important to work out the relationships between water deficiency and nitrogen deficiency, particularly with respect to agroforestry systems. Water is often thought to be the limiting factor in crop production. However, in many cases it may really be a nitrogen deficiency. Trees and perennials have deep root systems and are able to explore the soil volume very signifcantly resulting in more efficient use of water. In addition, these trees can extract nutrients such as phosphorus and potassium from deep horizons of the soil and transport them to the top. In a sense, then, they become nutrient pumps. Research is needed to document this in real farm situations where external inputs are not available to solve this problem. Where phosphorus is a problem, sources of phosphorus such as indigenous rock phosphate should be researched. Application methods also need to be considered to increase the efficiency of use of this material. On acid soils with low pH we need to continue to look at ways of partially eliminating the soil acidity to increase nutrient availability and enhance the nitrogen fixation package.

Another strategy that somewhat transcends all these issues is to continue to look for or find plants or breed plants which tolerate adverse conditions. Most strategies deal with changing the soil in some fashion. Another strategy is to find plants that simply do well under less than optimal conditions. In many cases there may be indigenous plant species which perform quite well under these conditions and they are simply ignored or simply not part of the production system at this point.

An area that needs research is the area of multiple cropping. This production system potentially has many efficiencies in it and offers the low resource farmer significant efficiencies as compared to monoculture with respect to nutrient uptake, weed, disease and insect control. As population pressures increase, plants which produce highly are going to be a mandatory part of that farming system. Root crops produce much more per unit of land or resource used in general and therefore much research is needed on high producing root crops.

A very significant issue is the matter of pest control. We basically have two alternatives for pest control. One is a result of using artificially produced chemicals to control target insects. This system has only been around for the last 40 to 50 years, but we have learned that it works effectively at first and then it results in many problems as a result of producing resistant species or elimination of beneficial insects which upsets the natural balance and requires even more spraying. Environmental and health problems are also significant with this approach.

The other thing that happens as chemicals move into the farming system is that research and science tends to become occupied with the use of chemicals rather than trying to understand the biology of the system. An alternative, sounder approach is to breed resistant varieties, use cultural practices such as multiple cropping, or other cultural practices which keep the insect levels in control and yet does not create all the problems that the chemical approach does. It seems very clear that research on systems must take into account the control of weeds, insects and diseases, and holistically studying farming systems this type of information can be developed.

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Additional points made in the presentation:

1) Scientists have to break out of their tunnel vision or "canister complex". They need to be more creative in developing alternatives from the available resources in the specific agricultural systems.

Key discussions in depth

Dover: Bill, you talk about multi-disciplinary research. Having been involved with integrated pest management programs for a little over a decade, one thing that has really impressed me was how IPM research in the best programs have really benefitted tremendously by the inclusion of system scientists in the research design and implementation phases. That infusion of systems science as an organizing methodology, has been a tremendous boom to IPM research. I wonder whether your experience with developing country agriculture in this area, particularly with regard to resource conserving agricultural systems, whether you have seen any involvement of systems scientists in that and whether you think that's a real possibility.

Leibhardt: We have involved those kind of individuals. I think we have yet to see the fruits of that, but we have very much of a multi-disciplinary effort in our conversion project at the Rodale Research Center with both USDA people, people from the land grant system, and University people.

Francis: We had a systems engineer as part of our CIAT Small Farms Systems and we felt that was a really valuable component because it helped those of us in the agricultural sciences to look at things much more logically, if this, then what else, and I think it is extremely valuable. One comment, last week at the agronomy meetings as we talked about farming systems research with some of the Florida folks and Peter Hildenbrand gave a presentation. There was a lot of skepticism expressed about the result of farming systems. We've started the first steps. We've described systems; we've talked about alternatives, but we haven't gone through the steps of living out these alternatives, working with farmers to test and validate and actually go through the implementation phase. You cannot eat boxes and arrows and neat theories. It's true, but I think it is still a valuable approach and we need to get people talking to each other. It cannot just be the agronomist breeding the new variety that never gets adopted or the systems engineer drawing boxes and arrows that never lead anyplace. It has to be everybody working together.

Dover: What makes sense to me with regard to the use of systems science is not only can you try and get a sense of what system it is you are working with and trying to characterize that, but also to try to establish some fairly concrete ideas as to where you are going. What are your objectives? What is that system going to look like when you are finished?

Morgan: This is occurring for domestic agriculture at Rodale Research Center in that part of the network that has been formed in the presence of the USDA scientist. We do have a systems analyst there in addition to Jerry Radke, a physicist. What they are finding is that as they move from physics and chemistry measurements to biological measurements, the number of parameters just almost explodes in terms of what has to go into the models, and so it is becoming extremely complex to deal with, but they are trying to do this in order to incorporate them, but it is a very difficult problem to deal with. There also has to be a way in which that system works on a farm so they have committed themselves to a farm management application on what they are talking about in research, and we think that is an extremely important step.

Sands: I think that one of the importances of the idea of the systems approach is not only to have a schematic as to where you want to go, but also of what you are actually starting with. I think many of "the problems with farming systems research" so far is that when Peter Hildenbrand popularized that methodology six or seven years ago, many projects that had already been designed, and were in the pipeline, were not conceived or designed as FSR/E and instead were conventional research and development projects that then had the FSR/E philosophy/methodology laid over them when FSR/E became the new buzzword in USAID. They are not true FSR/E projects. In the next 3 or 4 years we should see more positive results as true FSR/E programs start to really test alternatives.

Wheeler: When we started Winrock we based it on the systems program and always looked at it that way, as an institution. It's one thing to have a philosophy, and I think it is good to look at the interactions, overview, disciplines, and so forth. Then you get down to the practical reality of running an institution. I would be a little hesitant about organizing simply around various systems and abandoning research in narrow areas. Systems approaches can also hide a lot of evil.

Leibhardt: I'm not suggesting we throw out departments. Organize along departmental lines in many cases. It seems to me that what we need to do is look at how colleges and agriculture in general define problems and potential solutions. It seems to be that this administrative award system has to be changed in that even though results come from a body or a larger research project team members are recognized as team members, not just as individuals.

Summary of other Discussions

Scarborough: Can we assist training officers to find curriculum, teaching aids, etc. for a research and field person?

Leibhardt: They will need a multi-disciplinary approach.

Dover: Gordon Corwell's "Agroecosystems" workshops strongest feature is the development of a common set of objectives and language. We need to develop an agenda for research.

Winter: I support the concept of multi-disciplinary research, but we don't have all that many researchers. We must concentrate on one thing or there will be no results.

Mayberry: There are glimmers of hope in Africa. ISIPE in Nairobi has an integrated research graduate student program. ANSTI (African Network of Science and Technology Institution) is a research engineer network.

Barry: Practical on-farm work is not in U.S. agricultural schools enough. The agricultural institutions in Australia include 2 years of on-farm work plus work in the classroom and one day a week on a farm.

Kramer: The barriers we face are from the institutions. Why not abandon the institutions and look for alternatives to them? Why not use village institutions or use an indigenous structures?

Mukusya: Many farmers are women. They have 5 to 7 children and are hip deep in problems as it is. Research stations have not changed farmer's activities. Farmers accept ideas better from other farmers. The best way of finding solutions is to go to the people and forget about research stations. If the idea is good, the farmers will take it and it will spread like fire.

Soos: How can we get the first farmer started?

Mukusya: It's always a risk, but if one farmer risks and succeeds, it will spread.

Cooper: What about para technicians. They are people from the community who have the farmer's trust. They reduce risk for that farmer and other farmers, too.

Morgan: This model succeeds. It's not as much theory as practice that is difficult.

Meyers: As far as training is concerned: Generalist vs. Specific. There should be both. Generalists don't always see specific problems.

Haberern: Rodale is not an agricultural institution, but has been able to affect change as an information disseminator relaying information from farmer to farmer.

Soos: Africa's needs are immediate. Is spending half our money on research the most effective solution to Africa's problems? Should we be building research stations in each country or in different regions?

Morgan: Our bias is research, pragmatic consumer driven research. Collaboration at all levels is desirable, but difficult. After one year, results are coming much more quickly and there is a glimmer of hope. Women's involvement is absolutely necessary.

Wheeler: On the education/human resource questions, government and leadership is guilty. The existing political system is like beating our heads against a wall. Africas leadership leaves their countries no opportunity. Educating national scientists in the U.S. is great, but if there are no incentives to return home and work, there is little benefit to the country.

AGRICULTURAL POLICY

C. A. Francis

AGRICULTURAL POLICY

Charles A. Francis

INTRODUCTION

There is probably no topic more aggressively pursued by national governments and by international and bilateral assistance programs than agricultural policy. This is seen by people in administrative positions as the key to progress in the agricultural sector, more important even than the availability of any specific types of technology. A comprehensive treatment of alternative approaches to agriculture must include discussion of policy options, although there will be little agreement on specific directions or ways in which particular questions can be resolved.

More useful to policy makers is the presentation of a series of issues which are relevant to the development and adoption of production practices which promote a more regenerative agriculture. There are many decisions which are a part of the planning process in the agricultural sector which can have a direct and meaningful effect on the success of agricultural practices which promote food production, family income and nutrition, and the long-term sustainability of the agricultural sector. Since it is difficult to prescribe specific solutions to each of these issues, and the needed decisions are somewhat country- and region-specific, this background paper presents a series of questions. After stating each question or area of concern, the policy maker can proceed to evaluate the importance of each question and consider the range of alternatives which are relevant to country or region. This is more valuable and more credible than a set of prescribed decisions and directions for policy.

There is much overlap among these areas of concern, and in farming systems there are significant interactions among most of the biological, economic, social, and political factors which influence the decision making process on the farm. Thus, there is no way to confidently separate these issues nor to make them independent, one from another. This explains the overlap and at times redundancy of information which is presented.

Serious consideration of these issues in the context of farming systems, especially in areas where farmers must operate under the constraint of limited resources, will result in an integrated set of agricultural policies which can promote the development of regenerative agriculture. This is a valuable approach to producing more food with available, internal resources on the farm, and one of the key elements of total agricultural sector policy which will lead to long-term food supply and greater economic, agricultural, and ecological stability.

POLICIES IN THE INFORMATION AREA

Agricultural technologies and alternative practices which lead to more regenerative agriculture are highly dependent on information. In fact these approaches may be called "information-intensive" or "management-intensive" strategies to farming systems. It is imperative that emphasis be placed on information and the creative use of human potentials as a substitute for expensive, imported inputs for agricultural production. This is a big element of regenerative agriculture.

Collection of Relevant Information

What data exists in university, ministry, and private organizations which could be used to design strategies for a more regenerative agriculture? An evaluation needs to be made of what information is available in the agricultural sector and on specific production practices which have been successful for farmers. The emphasis here is on technology which makes maximum use of resources which are internal to the farm, and can be used without excessive dependence on outside capital or inappropriate technology. An inventory of information resources would be one approach to getting this baseline data. This information may be available, or may need to be collected from primary or secondary sources. The important focus is on information as a component of future management strategies, and not as an end in itself.

Information Processing, Reduction, and Storage

How can information best be processed, analyzed and reduced in volume and screened for relevance, and then stored for maximum accessibility by those who will make use of the files? In order to make an information base readily useful to the researcher, extensionist, and policy maker, there needs to be an organization and interpretation of what is available and has been collected. This requires a system of identifiers or key words, a storage method which will permit access to information on a timely and efficient basis, and a physical storage system which is consistent with the resources available and experience of the people who will implement the system. The physical system could range from the simplicity of a box full of envelopes and file folders to the power of a micro-computer storage and access system with multiple stations linked through hard wire or telephone connections. The important thing is to set up a system and to make it work.

The reduction of volume or screening of information for relevance is a more critical step. The criteria for selection of data or practices to keep need to be established. These may include level of technology or inputs, availability of local resources to implement the practices, relevance to family nutrition and income, and effect on the environment. These criteria will provide a type of "sieve" through which all information must pass to be included in the data bank of appropriate practices. The criteria will also need to be reviewed as conditions of land resource levels change, or as target groups for technology become more clearly delineated. This is an extremely important part of the process, since criteria used to screen information will determine what is accessible from the data bank.

Finally, the physical storage of data can be done in a number of ways. The important considerations are to make this bank accessible to those who are going to need to converse with the information base at frequent intervals. Having a specialist in charge of the data collection who can be on duty at all times, and to facilitate the access by users would be an invaluable part of the system.

Information Publication and Distribution

How does technical information from the data resource reach those in research, extension, and administration who need to make use of this for decision making? People need data in different forms. The agricultural scientist who is developing a recommendation for a rotation or fertilizer application needs detailed data on what has been done in the past and how the results were influenced by soil type, cultural practices, and rainfall, for example. This same information on fertility is most useful to the extensionist if presented in recommendation form, ready to be translated into publications or other vehicles for delivery to the farmer. And the policy maker needs a brief abstract of the information with the crux of the results available quickly to be able to apply this to policy decisions. This information needs to be packaged or available in a range of different forms for those who will access this resource.

Access to International Information Resources

How does a national program best access the relevant information from international sources? There is a multitude of information sources now available in the international community. These sources include libraries, journals, data banks, current research and extension reports, commercial company data and promotional information, and the wide range of "clandestine" or "grey" literature which is found in people's files and experiences but never reaches the stage of publication. The world's "information explosion" is present in agriculture just as in other areas, and the sorting and access of this resource is a complex one. The only solution which is not acceptable is to ignore this resource.

Similar to the collection and evaluation of data at the national level, there is a need to screen what is available internationally before using ideas and technologies. It would be a heroic task to review everything. The efficient approach is to let other organizations provide the first cut at screening or sieving this information. By accessing on-line data services, a technical person can screen large numbers of articles without having to order them. There are abstract services and active research libraries in all of the international research centers, and these can provide regular and inexpensive access to a wide range of information on specific crops.

More difficult is the access to reports, mimeos, local bulletins, and to unpublished experiences of researchers. There are people who travel and work with many national programs and research stations -- many of them are in the international centers and other organizations with wide access to people and information -- FAO, USAIDs World Bank, and others. Each of these groups has a publications section, and working directly with their libraries can provide dividends. There needs to be a conscious effort to bring relevant information into a national program, and to use this in an efficient manner -- the most important sources can be put into the same distribution network as the local data, once it has been validated.

Policies And Procedures For Setting Research Priorities

Much of the success of a research program comes in the setting of priorities. These are determined by a number of different people at different levels in an organization, and in some more integrated programs this process involves extension people and farmers as well as researchers and administrators. What are the relevant questions?

Farmer Involvement in Research Priorities

Should farmers be involved in setting priorities? Priorities in research most often have been set by those most directly involved -- the field research people themselves. Although there is interest and responsibility by directors of research and policy making boards, the primary input continues to derive from the perspective and opinion of researchers. There are some adventuresome programs which involve a wider range of people and institutions in decision making in research -- many of these are in the realm of "farming systems research", where the farmer is involved in identification of limiting constraints as well as the setting of priorities for how to solve them.

Farmer Involvement in Research Planning

Should farmers be involved in the research planning process? As well as involvement in the determination of constraints and setting priorities, some programs have individual or group participation from client groups in the planning and implementation of research programs. Especially when there are on-farm experiments as a part of the research process, farmers may participate in the detailed planning of types of trials, questions to be answered, and later interpretation of results. Research specialists usually have primary responsibility for setting up designs, specific treatments, and taking data. However, there are researcher-planned and farmer-implemented trials, as well as farmer planned and implemented trials in some alternative research schemes. Committees of farmers can play an important role in bringing a practical orientation to the conduct of a research program and the relevance of results.

Level of Appropriate Technology

What is the appropriate level of technology for new innovations? Many past efforts concentrated on "modernizing" or "up-dating" the agricultural sector, attempting to adopt components of technology and specific combinations of practices from developed regions. Often these have not been appropriate for the conditions and level of resources of the farmer in a specific location, and this has been responsible for the lack of success of the green revolution in many areas. It is difficult, but essential, to assess the resource endowments and constraints of the farmer and family in choosing the appropriate level of technology. And if there is research and development involved, it is critical to look down the road to determine the expected level of resources when the technology becomes available. Reliance on local and internal resources will require a different strategy and set of specific research priorities than a program which will depend on imported production inputs.

Food Crops Versus Export Crops

Should the agricultural sector concentrate on food and fiber crops for internal consumption, or on products for export? This is a vital issue which has an important influence on research strategies. Research in the past has often been dominated by work on high value export commodities, often grown with high technology and in the most favored areas. Any shift in national policy toward a goal of food self-sufficiency will require a corresponding shift in research, development, and extension priorities. There are a number of related policies in the agricultural sector which are needed to complement this research decision, and these are presented in later topics.

Role of Microcomputers in Agriculture

What will be the role of microcomputers in the development of research plans, in processing of data from the field, and in data storage and communication? Important for the screening, management, storage, and diffusion of information, the microcomputer provides a new capacity for the research program as well. Since many research organizations are dependent on a central computing facility and the specialists there for reduction and analysis of data, the capacity of micros present a radical potential departure from what has been done in the past. When there are potentials in the field to organize and analyze data immediately after it is collected, this adds an invaluable dimension to research and to the rapid communication of results to other parts of the agricultural sector. It is also possible to make decisions on management of research trials during the course of a season -- when to collect more (or less data from a trial, how to explore other details and interactions which were not a part of the initial plan, and how to modify objectives according to partial results during the season. All of these activities were difficult if possible at all before the introduction of the potentials of microcomputers.

Researcher and Administrator Role in Research Priorities

What is the role of the researcher and the administrator in setting priorities? Many developed countries have evolved to a state of relative autonomy in research projects, where research scientists in the field are somewhat independent of other levels in an organization and quite independent in their determination of priorities. This has been a result of academic freedom in university settings, and a result of favorable research support over a number of years. This has provided a climate for rapid advance in basic science, but has not always resulted in programs which are as directly focused on immediate field problems as programs in other parts of the world.

Much of the developing world cannot afford this luxury. The limited number of trained researchers and lack of adequate resources and facilities for research demands that attention be directed toward the most critical production problems which are faced by the country. This has often been achieved by a top-down management of research including setting priorities, using those few trained people in positions as administrators, such as a director of research. Such a position often has additional responsibilities including management of research stations, personnel and budget, and day to day detail work which precludes a careful study and planning of the direction of a research program. This clearly is not the complete answer in most situations.

A potential model which could work is the team approach to setting priorities, including input from farmers, extension specialists, researchers, and administrators. Although the researcher would be the implementor of the field work, a healthy input from the other levels in the organization can assure that the correct problems are being chosen, that the plan for solving these problems is sound, and that the resources are adequate for the job. The farming systems research approach to development is a logical framework within which to operate, and this is described in more detail later.

Policies To Promote The Research-Extension Linkage

Concern is often expressed about the lack of an effective working relationship between research and extension. The specialists in research place blame on the people and organizations who are responsible for moving information to farmers -- they are not doing their job! Extension specialists, on the other hand, often claim that the researchers are not focused on the right problems or do not provide timely or appropriate technology! Both comments underline the importance of a strong linkage between these two activities. This critical relationship is often lacking. When the two activities are administered by different branches of the government -- under different ministries, for example -- the problem is accentuated. Although organizational structure is discussed later, there are some specific questions which can be raised about the field linkages between research and extension.

Incentives in the Research-Extension System

What are the specific incentives for researchers and extension specialists in their jobs, and what are the incentives to work together? Job incentives are defined variously in different countries and specific ministry groups, but may include some of the following. Salary, housing, transportation, and crop incentives for family food supply are among the most common rewards and perquisites available in many research and some extension positions. Professional recognition comes from timely preparation and submission of reports, participation in meetings, and at times technical and extension publications. Although the list of rewards and types of recognition may be similar between developed and developing countries, the relative importance probably is quite different -- especially where salaries and research support are meager and other types of recognition are considered more important.

In many countries the only route to advancement and salary increase is through the promotion and administrative ladder. There is good reason to stay near the centers of power and decision, and often there is not a reward to spend time in the field with clients. It also may be most convenient and rewarding to place emphasis in both research and extension on conventional activities which are easily recognized and understood by those in positions of power -- and departures from these norms may be counter-productive. This is where organization, policy, and perceived rewards impinge on the potentials of individuals to make an impact on alternative, low-resource research results and recommendations to farmers. If this is not understood and accepted by those in power, it will be difficult for an individual or small group to go against conventional wisdom to move these new ideas into the agenda. This needs to be considered carefully by those who wish to make an effective change in the direction of research and extension. It also affects the potential for these two vital activities to work together, a type of linkage which is not generally supported by existing organizations.

Structure of Research-Extension Interaction

What types of organization would most favor interaction between research and extension? Although every country will have a somewhat different organizational diagram and list of responsibilities in each area, there are a number of models which can be useful. At the very least, a research-extension liaison officer can be appointed or office can be established to help communication and see that joint activities can be initiated and rewarded within the system. The USAID program in Botswana has been successful in this regard, with the MIAC/Kansas State project providing a key person to catalyze this linkage. It is especially critical when the two activities are placed in different administrative sections of the ministry of agriculture, or even under different ministries.

There are models where the research scientists work directly with extensionists and farmers. The maize research program in Peru not only develops and tests seed of new hybrids and varieties, the program produces seed of these materials for release and sale to farmers. The testing phase is run in conjunction with the ministry of agriculture research and extension people in each region of the country. This integration of functions has proven useful, and the sale of seed has financed in part the activities of the cooperative program.

The Bean and Cassava Production Systems Programs in CIAT in Colombia have worked closely with the national research and extension programs, as well as with non-governmental groups such as the coffee grower's federation, to bring new germplasm to critical testing under farm conditions. These national program and private agronomists who work with the trials, as well as the participating farmers, become a part of the extension process after the new materials are released. It is important to explore a number of these successful models, and see which are appropriate to help move low-input technology to the farm.

Farming Systems Approach to Development

How can the farming systems approach to research and extension fit into this overall scheme of development? Understanding of the FSR concept is complicated by the wide and indiscriminate use of the term in today's development community. Almost any project which involves an interdisciplinary team has been given this name when it appeared convenient for contractors and pleasing to funding agencies. Projects which effectively interact with extension and with the farmer are more limited in number. Thus, the opinions of decision makers in national governments and international funding agencies should not be overly influenced by the success or lack of same from experience with one project which used the FSR label.

Properly applied, the farming systems research/extension concept begins and ends with close farmer involvement. This includes identification of principal limiting constraints, design of alternative production practices and systems to solve those constraints, participation in the research and validation phases of field activity, and then in evaluation of results during widespread adoption of a new concept or practice. This approach builds in both extension and research an increased potential for overall success.

Setting Priorities for Extension

Who should participate in setting priorities for the extension service? Similar to the research situation outlined above, these priorities are often determined from the top down through an organization. Many of the same shortcomings of such a system are likewise a problem for extension programs. If there is an active role for field extension personnel and interested/involved researchers, and by farmers in the region of application, there is a better chance that the system of reaching the farmers can be effective.

The system used in the U.S. of having a farmer advisory committee in each extension region (county) is one model which might have relevance. Although much of this involvement is culture-specific, there may be analogs which would work in other countries and at other levels of sophistication in agriculture. In every culture, there are community and agricultural leaders who take a special interest in the programs in research and extension. Their involvement would help to ensure that programs of research and extension are closely related to real problems in the field. And the involvement of local groups in the extension process will help move new potential solutions and appropriate technology to farmers in the zone. This decision could be a radical departure from existing systems, but may be one way to effectively move regenerative technology to the farm.

Integration of On-Station with On-Farm Research

How can technical research on experiment stations best be linked with testing on farms? This is a difficult question, since much of the work done today is not linked between station and farm. Only a few types of research such as variety testing and fertility trials are frequently found on farms as well as on stations. Another model would be to view this series of research activities as a continuum, with some activities always carried out on station, some always on farm, and some on both station and farm. Development of new genetic combinations should logically be carried out under the controlled conditions of the research station. Final validation of cropping systems must be done on farms in order to make sure that the new technology is appropriate to farmer levels of resources and management. Some studies of ultural practices, however, could be done in both places. Radical departures from conventional practices should logically be done on station, while most promising new innovations which appear to be useful could be tested on farms. Changing row spacings, densities, crop sequences, varieties, or types of fertilizer could fit into this category. Much of the component technology in regenerative farming systems can be tested on farm, since practices are not radically different from what farmers are doing today.

Policies Which Apply To Specific Technologies

When we consider national development policies, and those which are specific to research and extension within that umbrella policy at the national level, we generally do not consider the effects of these policies on the potential for development and adoption of specific technologies by the farmer. Yet these are intimately related. The decisions to concentrate on export crops, to build a new fertilizer plant, to permit importation of a wide range of pesticides, or to build a new dam for irrigation all can influence the choice of crops and the management levels to produce them. Thus, these national decisions do impact directly on the decisions by the farmer, and can influence the potential for adoption of a regenerative agriculture. Several of the most important areas are discussed.

Decisions Related to Soil Fertility

What effect do national policy decisions have on enhanced soil fertility and increased potentials for crop production? A part of the success of rice and wheat in the intensive production systems in favored regions has been due to increased use of nitrogen fertilizer. The new short, stiff-stalked varieties were able to respond to this nitrogen with increased grain yield in place of more vegetation. This field practice has been supported by national decisions to import or produce more synthetic fertilizers at home. Although the results have been noteworthy, this has occurred at a price -- accelerating costs of imported energy to produce the fertilizer and side effects on the environment from excessive applications and from leaching of the nitrates into ground water. There are other alternatives, including crop rotations, use of green manure crops, intercropping, animal manures, perennial nitrogen-fixing trees, and others detailed in other sections. If these potentials of non-conventional sources of nitrogen and other nutrients are recognized by national governments, and if a research and extension effort is launched to fine-tune the practices and recommendations to use this approach, much foreign exchange can be saved by following this alternate approach. There is an educational as well as a research challenge -- soil fertility specialists trained in the use of soluble chemical fertilizers need to be convinced that these alternative approaches can work. And they will have an easier job selling this approach to farmers who will be more willing to adapt a system which builds on the resources internal to the farm than to the purchase of costly and poorly understood products from outside. There is also a benefit to the environment from use of non-chemical sources of fertilizer nutrients, those which are present on the farm in organic form and which can be intensified in their application for crop production.

Decisions Related to Weed Control

What are the alternatives available for weed control in crops, and how does national policy affect the farmer's decision? Conventional application of modern technology includes a strong input of herbicides for control of unwanted plant species. This has been possible in mono-culture with the development of selective herbicides for most major food and export crops. Yet the use of this technology is not without problems. The calibration of application equipment is critical, and dosage used on crops is very specific to make sure weeds are killed and crops are not. There is not the wide range of tolerances which characterize use of insecticides and fungicides, chemicals which have been used by farmers of different resource levels for a longer time. Thus, control may not be complete or what has been promised by the chemical companies. Dilution or other adulteration of the products provide another problem, and a situation in which the materials will not work as recommended.

Finally, there are residue problems in food which were not thought to be a problem for animals during the early years of herbicide use -- today there is more concern about these residues.

Other options are available for weed control. Accepting that weeds are a serious deterrent to crop production, and that unwanted species may limit the area under cultivation more than any other single factor, there is need for careful consideration of these options. Crop rotation, use of specific crops under vastly different cultural conditions, and fallow periods help to control weeds. When there is a cropping sequence which is counter-cyclical to the life cycle of weeds -- such as a wet/dry season, upland/flooded season, or hot/cold season -- there can be considerable control of weeds through this crop and season cycling. Management schemes can be designed to take maximum advantage of these potentials. National decisions to permit importation of chemical products, their regulation in the country, and the registration of certain products for certain crops is an important part of application of today's herbicides. Yet the sophisticated system needed to monitor this level of control most often is lacking in developing countries. This should lead to serious consideration of alternative methods of control, and national decisions which will promote their use.

Decisions Related to Insect Control

What are the options for insect control in cropping systems, and how is this affected by national policy? Most of the considerations listed under weed control apply to insect control as well. There is a wider range of tolerance in the use of insecticides, at least in regard to plant survival and growth. At the same time, there is more concern about toxicity to humans and other animals and about residues in food products. Some export or commercial crops such as cotton are characterized by incredible applications of pesticides -- up to 12 or 15 spray applications per season to control unwanted pests. This is an extreme case, but there are other crops which also are sprayed with regularity.

Some of the options mentioned for weeds are appropriate for insect control: crop rotation, cultural management of crops, different types of conditions in alternating seasons. Other methods which help in the control of insects include suspending spraying to allow build up of predators and insect parasites, clean culture to eliminate crop residues and alternating crops. This last approach is especially desirable for the farmer of limited resources, since the control can be acquired along with the seed -- and the seed of varieties can be saved with care from one season to the next. This is less feasible with hybrids, but open pollinated varieties or varietal crosses can be used in the same way as varieties -- even in cross pollinated crops. The national decisions to emphasize research on a specific type of control can influence what is available to the farmer. Likewise, the decisions to import and control use of chemical products can influence their cost and availability. These factors need to be considered carefully during the design of a development strategy.

Decisions Related to Disease Control

What decisions made at national level can influence the types of technology available for control of plant and animal pathogens? This subject is closely related to insect control in almost every way. There are not chemical controls available for many plant diseases, at least not in an economic way. Thus, the cultural and genetic controls listed would have to be employed. Also, there is better genetic resistance to many of the major plant pathogens, compared to destructive insects in plants, and thus the genetic approach may be favored over others. Research decisions and priorities, extension efforts to move different types of technology to the farm, and decisions on import and control of chemical products also influence what is available to the farmer -- and this is where national policy influences control options available at the farm level.

Cultural Practice and Tillage Options

What are the policy decisions which influence the speed and profitability of mechanization on the farm? Agriculture can become more efficient per unit of human energy and time through use of machines. This has been the basis of the agricultural revolution in much of the world. Unfortunately, the application of this principal to much of the developing world has not given the same impact, and has produced some undesirable side effects such as large investment of capital and energy reserves. One of the reasons for slow application of this technology has been lack of implements and capital to purchase them. Problems of maintenance on the farm, where trained operators and mechanics are in short supply, has also slowed their use. Many of the tractors and implements available are not well adapted to difficult tropical conditions, and are not easily repaired in a village shop -- they are dependent on an efficient supply line for parts and service. Most difficult of all, other sectors of developing economies can easily pay more for the fuel needed to power farm machinery, and it is difficult for agriculture to compete. Some analysts conclude that agriculture in the developing world has, for the most part, not entered the fossil fuel era. They further speculate that agriculture is unlikely to reach this stage, given the other demands on energy supply and the high cost to the farmer.

A number of practices which have become accepted in more developed agriculture include minimum or zero tillage for erosion control and saving of moisture. This also eliminates the need for some of the cultural operations in the field. This is dependent so far on heavy use of herbicides, and the difficulties associated with this technology were outlined above. Countries need to explore creative methods to grow crops in multiple species sytems, with overseeded legumes to help control weeds and produce nitrogen, and use other innovative systems which will minimize the needs for heavy equipment and primary land preparation. These are priorities in the research programs, and are influenced by the assignment of resources for research. Decisions to import equipment or to build assembly plants also must be made. If there are uses for certain types of appropriate machinery, and a labor resource can be used to build these machines and export them to other neighboring countries, this may be a rational decision. The important focus is on appropriate machinery, easily understood and repaired, and of the size which is useful to farmers with limited resources. The potentials of cooperative ownership or use of machinery is also a route to explore.

Choice of Crop and Animal Species

How does choice of crop and animal species for a farming system influence success in agriculture, and how can this be influenced by national policy? The decisions of crops for food versus export commodities is important and discussed elsewhere. The need for basic food commodities is obvious, and national decisions to favor food crop and animal production is important to national food security. Experience has shown that innovations in crop/animal systems are most readily accepted by farmers if they do not differ radically from the crops and animals currently used in a system and an integral part of the diet. Yet many of the most important basic food commodities in each country today come from another part of the world. This indicates that there is flexibility in farming decisions, in production systems, and even in diet. For a new crop or animal species to be successful, it needs to meet a perceived need of the farm family, and needs to be well adapted to the environment into which it will be introduced. Crops which fit a specific niche in a system will be favored over those which require a drastic change in the entire cropping system. Use of more drought tolerant species can be one route to increased production stability -- substitution of sorghum for maize in Kenya, or of pearl millet for sorghum in Botswana or the Sahelian countries, is an example. More moisture efficient or drought-tolerant legumes such as black beans in place of other types can make a system more tolerant to environmental stress conditions. And shorter-cycle crops which are well suited to a particular rainfall pattern can be introduced into a system to improve its stability. This is a risk-reducing strategy by the farmer, and the approaches can be favored by decisions on specific research strategies by the government and research establishments.

Choice of Varieties and Hybrids

How can development of new varieties and hybrids make an impact on food production under limited resource conditions? Much of the plant breeding effort has been directed toward building more stress tolerance into the principal crop species. This includes tolerance to drought, extremes in temperature, deficiencies or excesses of specific mineral elements in the soil, and adaptation to other periodic stress conditions. This is an important priority for plant breeders today, yet most of the new varieties and hybrids released to date have found application primarily under the most favorable conditions in each country. This is because the experiment stations are located in the best areas, and because the demand for new technology has primarily come from those farmers who have the access to inputs to control the environment and produce consistent yields with high subsidy of fertilizer and pesticides. There has been limited testing under marginal, low-input, resource-poor conditions. There has been virtually none in the multiple-species systems which are often found on small farms.

The decisions at the national level to address the variety hybrid needs of limited resource farmers would drastically change this focus. There would be a new effort to test existing cultivars from within the country, and from other national and international programs, under farm conditions where resources are limited. There would be greater attention to the best production per unit of limiting factor: water, nitrogen, phosphorus, or other nutrient, as compared to production per unit of land area or per unit of labor. There would be a greater emphasis on crop quality, since a large share of production is consumed by the family or by people in the immediate area through barter or local marketing.

BUILDING A HUMAN RESOURCE

The most critical and important resource in any country is the human potential which the population provides to solve the challenges of food production and development. There are a number of national policy decisions which influence the training, encouragement, and mobilization of the human potential to solve national problems. These include the educational and job-related infrastructure, the salaries and other recognitions for trained people, and the continuity which can be built into positions and institutions. These factors are described in a series of questions and discussion statements.

Education in the Rural Sector

What emphasis is placed on education in the rural sector, and how do these students advance within the system? The basis for progress, according to most analysts, is to educate new generations for future contributions to society. Often the rural population is most disadvantaged, due to long distances from resource materials, poor facilities, and difficulties in getting trained teachers to live and work in the areas. A country needs to place priority on development of the rural educational system if this sector is to gain access to education and the potential which graduates can bring to development and adoption of new technology. Decisions on the priorities to be given to this activity are a part of the national strategy for development.

Education and Training of Farmers

What priorities will be given to farmer training and adult education in the national strategies for development? Although costly due to dispersion of the clients and often a lack of facilities and methods to teach adults, the training needed for farmers is critical to development. When new or modified technologies are presented which are information-intensive or management-intensive, there is a greater rather than a lesser need in the rural sector for this improved training capacity. As more activities are carried out on the farm and in the community using local resources, and as systems are developed which place greater value added on the farm and in the immediate region, new skills and information are needed by people who will implement these innovations. The development of the necessary infrastructure is a critical part of this strategy.

Education of Women

What will the government's policy be toward education of women, especially in the rural sector? Greater emphasis is being placed on education of women in some societies due to pressure from international funding agencies and bilateral projects, and because of the realization that this is one of the greatest untapped resources available to a country's agricultural sector. This is difficult in some cultures because of traditional roles for men and women, and because of the non-participation in formal educational activities by women. The knowledge that women make up the majority of the work force and a significant part of the decision making force in agriculture in many countries is influencing decisions about basic education. This will have far reaching consequences not only in terms of women's potentials to contribute to progress in agriculture. There will be a new awareness of old inequities and some social pressure for change in a wide range of areas. Governments need to be aware of the potentials for change, and to prepare for this in national planning.

Education of Disadvantaged Minority Groups

What provisions are being considered by governments to bring minority groups into the main stream through education and training? Often living in isolated areas and in some of the least favored land areas, minority groups constitute a significant portion of the population in many developing countries. They are a part of the production system, as well as important consumers for agricultural production. As their role becomes better understood by national governments, there needs to be special provisions to bring education and training facilities and resources to these areas. The potential of these groups have not been realized by countries in many parts of the world, for economic, social, and political reasons -- these factors are changing, and government policies need to evolve as well.

Training of Research Specialists

Is there an adequate national plan to train research specialists for agriculture? Training has been given top priority by many countries emerging from the colonial era, yet most of this training has followed traditional academic lines. Universities in most developing countries have been patterned after those of the previous colonial power, or after those of another developed country which provides financial or educational aid. In few countries have the unique needs and resources of the country been considered in the design of a secondary and university curriculum and program of studies. In general, a theoretical education has received priority at the expense of practical training -- resulting in a generation of technicians who have good basic skills but lack the confidence to tackle real world problems which face the rural communities and farmers. Graduate study in the U.S. or Europe has given high level training in science and humanities, but at times little which is relevant to the real world to which these students return. A part of the strategy for development must consider the real needs of the agricultural sector, and a training plan which is consistent with those needs. The training for research specialists in regenerative agriculture and effective use of internal resources is difficult, since few of the current mainstream institutions offer this as a significant part of the curriculum. This will take a maximum amount of creativity by each country and the funding agencies which help in the educational effort.

Training of Extension Specialists

How will extension specialists be trained and supported in the plan for agricultural development? All of the above constraints described for research personnel also apply to those in extension. However, the extension activity generally is given less priority and the people who are given positions to implement the movement of technology are more poorly trained, supported in their work, and rewarded by governments. There is a general feeling that extension personnel are second class citizens. In the implementation of a program which emphasizes use of internal resources, teaching of new management skills, and application of the farming systems approach to research and extension, the people working directly with farmers are a critical link in the team. Governments need to give more thought to how these agents are selected, trained, supported with transportation and other resources, and paid -- in relation to those in research and teaching. This area needs to be given much greater attention in development planning, especially as new and appropriate technology comes on line and needs to move onto the farm.

Orientation of Administrative Personnel

How can administrators best be made aware of the alternatives available to farmers through the regenerative agriculture process? The orientation of key administrators is an important part of any development strategy, especially one which involves substantial changes in the types of technology which will be developed and extended to farmers. Of equal importance is the emphasis on internal resources and human creativity to help solve problems on the local level, this being a large departure from the accepted approach of top-down management and decision making at all levels. This will be difficult in some cultures and many government bureaucracies. It will be seen as a threat to power and jurisdiction over decisions and progress in the rural sector. There will need to be careful thought given to how people in decision making positions should best be approached, and how this new concept can be sold. The collection of key data on how the process and its results can benefit a country needs to be carefully calculated and well articulated to those in charge. It needs to be <u>their</u> program, and not a pet project of one university or bilateral assistance team. Only when the entire process is internalized will this move forward with national support and wide impact.

Setting an Appropriate Reward System

How will agricultural specialists in the rural sector -- researchers, teachers, extensionists, administrators -- be evaluated and rewarded for their activities and contributions? Many systems are designed for rewards connected with promotions, move into administration, and as quickly as possible move into the capital city where decisions are made. People are quick to sense where the centers of power are found, and how they can most impress the persons above in the system. Such a system works to the detriment of specialists who would like to dedicate their efforts to solving problems in the rural sector, working directly with farmers, and being absent for lengths of time from the capital. Often there are not resources provided for travel, or for the research or extension materials needed to do a job. This is frequently mentioned by those who want to do a credible job in the rural sector, but find that resources are moved away into other sectors of the economy or into an unnecessarily large administrative unit in each ministry or other organization. Specialists respond to reward systems, and these incentives need to be given special thought by those in national planning.

Permanence of Personnel

How can a country best maintain a permanent cadre of well trained and oriented specialists in the field working in the rural sector? This is related to the reward systems outlined above, and also to the opportunity costs which specialists perceive in options outside the public sector or outside the country. It is difficult for the government of a developing country to compete with private industry in that same country, and especially with international research or development agencies which offer salaries and perquisites which are very attractive. Although it may not be possible to meet the same salary levels as those offered by other sectors or other countries, every effort must be made to be competitive.

There are other advantages to working in one's own country, near family in a familiar culture and language, and the government can build on this positive opportunity with the salary and support necessary to retain key people in research, teaching, and extension. Some technicians complain about lack of support for their work, accepting that salaries will be low--but they are willing to work if supported in order to serve their country. The development of regenerative agricultural systems is not something which can be done overnight. There is no magic formula, no special chemical to spray on the fields, no single new variety which will revolutionize agriculture. On the contrary, this is a stepwise process which builds on the knowledge of the farmer, introduces some of the benefits of science and new technology within that system, and requires continuity of effort from all involved. Thus, the rewards for specialists need to be carefully considered in a national plan, and the incentives to stay in these programs made as attractive as possible.

NATIONAL AGRICULTURAL POLICY

When considering national policy, it is essential to think about decisions at the national level which will impinge directly on the incentives and successes of the farmer. These factors and decisions include setting prices for basic commodities, policies for imports and exports of food products, import or manufacture of agricultural inputs, and allocation of resources to the agricultural sector vis-a-vis other sectors of the economy. Political issues such as land tenure policy influences the decisions and time frame of the farmers who are making plans to improve the long-term fertility of soils. And the level of government at which planning takes place is important -- whether there is strong local autonomy or whether decisions are dictated from the national or regional level. These are all factors in the setting of national priorities, and influence the potential acceptability of different types of agricultural technology.

Price Support for Basic Food Commodities

How do rice supports for basic food commodities or lack of the same influence the farmer's incentives to produce and the adoption of alternative technologies? There is a real and direct effect of price received for commodities and the incentive for the farmer to produce. This has been handled in some countries by establishing a basic support price, although this has not been successful in most situations. The great differences in price between neighboring countries, the potential for informal trade across national boundaries, and the consumption and trade of a large portion of national production in local communities has lessened the effects of price supports to stabilize commodity prices and guarantee an incentive to the farmer. Often the price set by the government is low, and the delay in payment from the government so great that farmers will not sell through official channels. Some governments have maintained commodity prices at an unrealistically low level, from the producer point of view, in order to maintain cheap food, curb inflation, and promote urban support of the government. This has worked to the disadvantage of the farmer. Certainly any financial disincentives will make the farmer less likely to consider new technology, especially if this will increase costs of production and risk. If regenerative technology and greater diversity in cropping leads to more dependence on internal resources and better exploitation of local markets, the farmer can become more independent of the national government and financial policies -- in this case the price supports will have minimal effect on adoption of technology.

Import Policy at the National Level

What are the effects of food import policies on farmer incentives to produce and on adoption of new technology? As imports of food grains influence price, this has many of the same effects on farmer incentives as the factors listed under price supports. Since farmers may ignore price supports in many countries, the effects of imports may be much greater. In Ecuador just before harvest of the maize crop on the coast, there was a government importation of a large quantity of mediocre quality maize -- more was paid per ton for this maize than the farmers were given as a support price in the country. This reduced the price in the market, and farmers with a better quality product raised locally could not compete with the imported grain. Although imports may be necessary for disaster relief, and to ease short-term shortages in some countries, the decision to import and the price set on the grain must provide incentive for local production or the production of food will suffer. If the crop is not profitable, farmers will be unlikely to adopt any new technology which results in higher risk. Again, introduction of cost-reducing technology which depends on internal resources, and greater diversity in the production enterprise, will provide greater independence to the farmer if more can be sold, processed, and consumed in the immediate area and on the farm.

Effects of Export Incentives and Government Priorities

What is the effect on farmer decisions of government policies on export crops versus production of basic crops for local markets? With a serious shortage of foreign exchange to pay interest on international loans and to import the elements needed for stimulating development, countries have often turned to their agricultural industry to generate income. This has only been possible through production of crops which are needed by developed countries for food or feedstuffs, and the diversion of hectares to this export production has meant less food produced for local consumption. Although there is value in the concept of specialization and comparative advantage in producing crops most suited to a special environment, this has resulted in a food shortfall in many countries as a spin-off from the export crops emphasis. Because of the lucrative markets abroad, much of the best land has been dedicated to the export crops. If there were an assured price for the export commodity, and if there were free trade and no complications in the world market, this sytem might work. Yet fluctuations in world price, trade embargos for political reasons, and lack of infrastructure to move food to areas where it is needed have caused a breakdown of this ideal system. The result in the best of cases has been short-term gains in foreign exchange and only intermittent shortfall in food supply. In the worst of cases, world price for a specific commodity has gone down, markets have been lost, income from international sources has become scarce, and food production and supply at the local level has become very short. The people at the end of the supply line, the rural farm families, have been the ones to suffer the most. A national policy which limits export encouragement to those crops and animal products which have an assured market, and keeps those exports to the minimum needed for foreign exchange, would be desirable. In conjunction with this deemphasis on export would be incentives for farmers to produce basic food commodities needed in the country. If there were encouragement to transform the agricultural sector using regenerative practices, there would be much greater production of needed food crops and animal species near where they are consumed, and this problem will solve itself -- at least at the local level. The government still needs to cope with the shortage of foreign exchange -- but there need to be other solutions than to destroy the potentials for local food production and supply.

Policies on the Importation of Production Inputs

What is the effect of government policy on importation of production resources from the international market? Most of the fertilizers and pesticides currently used by farmers in many developing countries are imported from outside. This is accomplished at great cost to the country in terms of foreign exchange and to farmers in terms of high production costs and increased risk if the technology has not been adequately tested. Yet these inputs have been the core of the systems recommended under what we call the "green revolution". To many agricultural experts and planners, their successful application is synonymous with agricultural development. The costs and shortcomings of this approach have been detailed earlier. In the regenerative approach to agriculture, the emphasis is on efficient use of resources which are internal to the farm and region. When this philosophy is applied to agricultural production, there is a drastically reduced need for imported inputs, and this problem will be solved. There is a net saving of foreign exchange by eliminating the importation of expensive inputs, as well as greater stability in the production system -- the reliance on imported products is fragile for the same reasons that were given for a dependence on export markets. This change in philosophy and orientation of agriculture will be difficult, since many of the decision makers and scientists in this industry have been trained in traditional high-technology methods which include maximum use of outside inputs. Because industry, both national and international, is promoting the sale of these proprietary products and there is substantial financial incentive for them to continue to do this, there will be additional opposition to any change toward reduced input use. The situation is further complicated by informal arrangements with national decision makers who are poorly rewarded in their official positions, but can be persuaded by private industry to help promote a certain direction in development. There is a critical need for highly motivated scientists and administrators to collect the relevant data to support changes toward a more self-sustaining agricultural industry, and one which can improve the production environment rather than continue to degrade it.

Building an Industrial Capacity for Production Inputs

What emphasis should the government put on development of local fertilizer and pesticide industries? This move has been cited by many as the approach which will bring greater self-reliance to countries of the developing world, by reducing their dependence on international suppliers of these needed products. If the technologies appropriate to a regenerative agriculture, based on internal resources and local human creativity, can be worked out through research and demonstration, there will be a reduced need for the industries described above. If there is a deemphasis on this phase of industrial development, the same resources could be dedicated to development of infrastructure which is badly needed in the rural sector -- schools, health facilities, roads, communications, and other elements which are usually not well developed in remote areas. Again, these are difficult decisions, and a government must be convinced of the value of the alternative systems and the results which will accrue to the farm family and entire rural sector. Governments must also be concerned with producing enough food for large and growing urban populations, and these systems must be shown to efficiently produce the food needed for people in cities as well.

Effects of Land Tenure on Development

What are the effects of the land tenure policies and their implementation on a regenerative approach to agriculture? In considering land tenure, there needs to be a distinction made between the laws which are on the books in some countries and the actual application of these laws. If there is an effective system which provides land for those who have a direct and personal reward from cultivating that land, the decisions in production of agricultural crops may differ from those in which share cropping or an uncertain ownership or tenancy exists from year to year. Especially in systems which are designed to build the long-term fertility and production potential of the land resource, there must be some permanence in the tenure situation. If tenure is short, especially from one season to the next, there is no incentive for the farmer to build a long-term potential for improved fertility, organic matter, reduced erosion, and careful stewardship of this vital resource. On the contrary, the incentive will be to exploit the land during the current season with little thought to the future. These policies and decisions by national governments are critical to the successful implementation of a long-term agricultural strategy based on internal resources and improvement of agricultural potentials and the environment.

Policies for Credit in Agriculture

How important are credit policies in the implementation of these new programs? There have been difficulties in getting credit to limited resource farmers in the past. Due to their lack of education and political power, there has been limited push by this sector to get access to credit. Even when international funding has been earmarked for the small farm sector, banks have found it difficult to manage a large number of small loans and have opted instead to fund medium and large landholders who have the collateral and experience in banking negotiations. Although there is need for some credit and finance of equipment and production inputs in an improved production system in the limited-resource sector, this should be greatly diminished by application of the principles of regenerative agriculture. With the greater dependence on internal resources and on locally available production inputs, there should be a reduced need for outside capital. It would be most desirable to promote the use of local and regional resources to stimulate this production approach, since this too leads to greater local autonomy.

National Planning in the Agricultural Sector

What is the effect of national planning on the success of a regenerative agricultural sector? Many of the above factors are a part of the national planning process. There are a number of policies which prevail today as a part of our conventional approach to development which is top-down and does not favor local autonomy, farm and regional independence, and a strong agricultural economy based on local food crops and markets. The decisions on food versus export crops, on price supports and import/export of commodities, and on control of imported chemical inputs all influence the access of farmers to this high technology and the incentives to produce one product versus another. National planning must take the long view in the agricultural sector, and determine what route has the greatest probability of success in gaining independence to the extent possible in basic food production and in the supply of inputs to agriculture. The approaches presented in this workshop are innovative and will not be easily understood or accepted by technical people or decision makers. As quickly as possible, local examples and stories of successes need to be collected and used to demonstrate how the system can work. There are many creative people in high positions, however, and if the programs are presented in a relevant way they should be understood and accepted.

Importance of Local Autonomy in Decision Making

What is the importance of local autonomy in decision making in development planning? One of the most difficult concepts to develop and implement will be a decentralization of authority and planning if that is desirable. There is little appreciation of division of authority, and this may be seen as a threat by many in national decision making positions. However, as education level and appreciation of the production process and regional economy increases there will be pressure for people in each region to acquire more control over their resources and future. This can be used to advantage to build a stronger regional and national economy, if the national leaders are willing to work together with local groups and provide those services which are most efficiently assumed by a national government. Most of these decisions will be very country specific, and dependent on the political system. Yet an increase in local autonomy rather than greater concentration of power in one center can help to build the rural economy and local organizations. If this is too sensitive a political issue, there are other areas on which to concentrate.

NATIONAL ORGANIZATIONAL ISSUES

In addition to national policy decisions, there are a number of basic organizational issues which can influence the efficiency of decision making and program implementation in the agricultural sector. Although it would be presumptious to assume that many or any of these organizational structures will change in the short run, it will be necessary to understand and work with the existing officials in the organogram of the ministries, and to appreciate how their many functions are interrelated. A number of issues are presented, including where agricultural decisions are made, how different sections of the ministries work together, how internal and international resources are organized and coordinated, and what types of integrated activity can best influence progress toward a regenerative agriculture.

Responsibilities of Ministries in the Government

How does the organizational structure of the official sector in agriculture influence the success of new development programs? It is a rare country where research, education, and extension are all located within a single ministry. The challenges of communication when these activities are found in different agencies are difficult. Even when two or more are administered by the same agency, there is often not a clear mandate for officials to work together. Thus, the many activities outlined above which require a close coordination in planning and collaboration in the field are complicated by physical and administrative distance. From experience in the field, we find that people at the grassroots levels in most organizations are willing to work together on specific projects, as long as there is at least passive acceptance of this activity by their respective administrators. It is necessary that their field activities be recognized and rewarded, even if not actively supported. The challenge of bringing the appropriate groups together for joint planning and development of strategy is an important one, since the field activities must complement each other to be effective. If one agency promotes alternative approaches to agriculture, using reduced external inputs and reliance on internal resources, and another continues to promote conventional high technology approaches, there is bound to be confusion and much loss of valuable time and resources in the field where they are already scarce. The research-extension liaison activity already described is one approach to overcoming distance and lack of communication.

Decision Making at the National Level

How are decisions made in national governments, and how does this process affect the potential success of new programs? Although much of the technology outlined in this workshop depends on a high degree of local reliance and internal resources, there is still a broad range of national decisions which can affect the program's acceptance and implementation. Many of these have been defined in this background paper. In working at the field level, a technician or project manager must be aware of the importance of national decisions and policies, and work to influence them when possible. Planning may be done by a section within the ministry of agriculture or production, or may have a special place in the cabinet. The first step to influencing the process is to determine where policy is set, and how the decisions are reached. What appears on paper or in an administrative chart may not reflect where the real decisions are made. There are usually strong vested interests in every government and national economy, and these may relate directly to decisions on a sustainable agriculture. When there are business interests involved, such as fertilizer or chemical importers and regulatory groups, these people will provide strong lobbies against any move by the government which appears to threaten their interests. Once these interests have been identified, and the procedures understood on how national decisions are made, programs can move ahead within this framework to influence decisions which can impact the project. This may be one of the most difficult parts of a project such as regenerative agriculture, yet could be one of the most critical to success.

Need for Integration of Activities

What mechanisms exist within the national organization to integrate activities at the field level to best support local development? A number of integrative activities have been outlined in research and extension. There are many other linkages and decisions at the national level which will promote or discourage integration of other programs which influence progress in local communities and rural regions. The development of transportation and other infrastructure has received priority in most developing countries, yet remains a difficult and expensive part of the development process. Often financed from national and international resources, with little local base on which to build, these programs have often favored a few areas and not reached much of the subsistence agriculture sector -- especially when farmers are remote from the capital and the current centers of economic activity and power. Some of the transportation needs which are specific to high-input agricultural development, movement of large quantities of inputs and transport of harvest, are minimized by a program which emphasizes dependence on local, internal resources and processing and sale of products at the local level. However, there is a need for some movement of inputs and commodities, and a serious need for effective communication channels. These are information-intensive systems, and the access to information will determine to some degree their success. Thus, the government is faced with the same list of important goals and integrative activities in this program as with other development schemes, yet the priorities among these goals and specific needs may be different.

Sources and Integration of Outside Support

What is the importance of locating and integrating international monetary support for these regenerative agriculture programs? Although the philosophy of local self-reliance and agricultural sustainability would lead to concentration of local resources to solve local production and marketing challenges, it is unlikely that this will happen without some outside infusion both of ideas and monetary support -- at least in the initial stages. Resources for development are scarce, and the approaches outlined in the workshop would lead to a much more efficient and productive use of those resources to produce food. It also outlines a scheme which makes best use of those resources from outside together with internal resources on the farm and in a region. Yet the programs are new, unique, and not well understood by most people in the development arena. Thus, the resources which do become available to support a regenerative approach to agriculture need to be carefully brought together and integrated with national resources to help local organizations, communities, and farmers to take charge of their production and markets. This will require a concerted effort by all who are involved with the international funding of such projects.

Integration of Efforts by International Organizations

What is the importance of the integration of international programs in the implementation of these new agricultural projects? Similar to the need for integration of financial resources, the human and planning activities of international agencies can be most effective if it is organized and mutually supportive in the country. It goes without saying that this effort needs to be carefully coordinated by people in the national government and be consistent with the goals which have been set. USAID programs have made an important step toward integration of efforts with other bilateral and international donors. The CDSS (Country Development Strategy Statement) developed each year by each mission includes a section which explores efforts in the coordination and integration with other donors. Although the concepts in regenerative agriculture may be different from what has been promoted in the past, there is still a vital need for coordination of effort. The existing channels for communication among international agencies and the exercises such as a CDSS from each mission can be used effectively to promote this integration.

CONCLUSIONS

There is no doubt about the complexity of organization which a major new focus would require in national governments, local projects, and the international agencies which support these activities. There is a critical need for local autonomy in these programs, and the development of a national strategy which fosters and financially supports local decisions is not an easy task. It is a complete change in focus for most government leaders, whose entire training and experience has been in top-down administration. Yet the potential benefits for a country -- in food production, self-sufficiency, local and national economic stability, and human welfare -- are too important to be denied. It will take a concerted effort to develop the methods and to communicate these to farmers who will be the implementors. More important, the farming systems approach and other schemes which involve the farm family and local community in solution of their own problems is an effort which will take all of our combined resources and ingenuity. Let's hope that we are equal to the task.

Additional points made in the presentation:

None made.

Key discussions in depth:

<u>Church</u>: I would like to suggest that you add labor to Bob's list. Use of labor and employment generation are extremely important components of development. One of the underpinnings of the development theory, and it is just a theory, is that linkage between agriculture and employment generates an important source of purchasing power. I've heard a lot of authorities on Africa discuss not only the scarcity of food in Africa, but also the scarcity of jobs. It's not unusual perhaps to discover that six countries in Africa have agricultural surplus in grains. These surpluses don't necessarily res lt from production surpluses in that there are people going hungry in those countries, but there's not the purchasing power for effective distribution. I am a little troubled by the impact that the regenerative agricultural strategy might have on employment. Now maybe you're getting at this and I assume that some of those technologies that are being introduced through regenerative agriculture approach labor use act employment in an African setting or an Asian setting.

<u>Bertrand</u>: Chuck, I like your bottom-up approach to policies, but kept waiting for you to say something about the overall national umbrella under which these policies would be supported. We can draw from the India experience where I feel that success was possible only because the Prime Minister and Parliment made the decision that they were going to improve agriculture, they were going to strive for self-sufficiency, they were going to do the educational job required, they were going to provide the inputs and they were going to provide the incentives and they held to that broad policy for years and years and years without quavering, and without that, I guess I feel that nothing really could have happened to the extent that it happened in India.

<u>Francis</u>: Both India and China which took a very centralized approach to decentralizing everything provide good examples. I think we have to build on these models and look at the successful components of these models and how they might fit in other cultures. If I were a leader of a developing world I think I would be looking around the world to see who has been successful, in what way, and what it took nationally.

<u>Johnson</u>: I happened to be in India in 1957. However, there were very significant differences, so when we compare India with Africa you have to watch these. India had a irrigation system. It had a transportation system, crude, but nevertheless it was there. It came in with the steel mills, with fertilizer plants, and with a significant number of foundation materials. The government did finally come together and the policy and the resources were all brought together with a sense of compassion to objectively let everyone in on it. In Africa we have talked to the Minister of Agriculture, the Minister of Health, the functional ministers, but we need to be also in the Ministry of Finance and the Central Bank. What are the pressures of the vice president, what is the environment that he has to cope with. The logic simply

doesn't come together and won't until we understand more thoroughly that I think we do what the African government is feeling.

Dover: I could not tell whether you were really talking about implementation of regenerative agriculture or improvement of conventional agriculture. What are the particular policies that regenerative agriculture needs? How are they specific to regenerative agriculture?

Francis: There are a lot of specific examples in the written text that I didn't talk about. An example: Does the government subsidize chemical fertilizer? Is it provided at a series of distribution points that also provide credit to buy it? Is there another approach that can be used which would take another approach to soil fertility?

Morgan: I think one of the things that have been sharpened for me as we have talked to some of you who visited Rodale about is where do policy concerns affect regenerative agriculture differently than conventional. There are some identifiable ones such as the matter of let's say building a fertilizer plant. It may not be necessary, you might be able to invest those resources more productively some other way. I think we are talking now in a larger area about the human factors, which are in essence the same for both regenerative and effective conventional agriculture. It's not so much agricultural problems as it is human, social, and political problems. Agriculture always occurs in the context, so we're back to humanity again.

Swanberg: I'd like to address the issue of macro-policies versus the targeted policies and it seems that for a long time we're not going to break away from a policy that favors consumption in most of the African countries where the political power base supports the regime in power. But maybe coming in from the bottom up you could identify some policy that would target on the technology transfer that you want. For example, don't put something that acts like a subsidy on fertilizer in general but maybe you could target phosphates because it's the phosphate that'll get the complete system moving rather than the nitrogen.

Dover: When I said what I did earlier, I did not mean to imply there was nothing being said about regenerative agriculture and some of the things you did bring up are of considerable interest. The subject of subsidies has come up a couple of times. At World Resources Institute they did a study recently on subsidization of pesticides. In that situation you're running directly counter to an integrated pest management approach which relies on the notion of an economic threshold below which you do not apply pesticides. If you subsidize the price of the pesticide then any application is economic. The same can be said about fertilizer. If that same amount of money were given to the provision of information, through an improved extension service, what would be the results? I wonder if anyone has done a cost benefit analysis of fertilizer subsidies, often using AID money or World Bank Money. What would be the benefits of paying the farmers to grow their own nitrogen as opposed to buying their nitrogen?

Summary of other Discussions:

Dover: Could we identify the criteria that AID or World Bank could use to evaluate projects?

Francis: We will discuss this in more detail tomorrow, however, in general we would favor those projects that focus attention on those technologies that make better us of the internal resources.

Ferguson: I like the paper, those basic questions such as, "What is the policy toward training?", "What is the policy toward research?", are often overlooked. I commend you on your emphasis on the practical and mundane.

Wheeler: We can't have effective research policies if the national economic policy isn't clear and effective. There must be a policy consistency across the agriculture sector in order to develop the capability to carry them out.

Morgan: At the Tanzania workshop, our strategy was to influence African researchers trained in the West. By Rodale (U.S.) scientists saying that it is OK to use manure and available internal resources, African scientists and policy makers were stimulated to focus on traditional resources, and existing practices.

Leibhardt: Back to the national government policies versus return to labor question. We have a cheap food policy in the US and most countries. The effect on return to labor is that unless the farmer is paid more, we won't keep people in farming.

Johnson: But researcher salaries in Africa aren't low in comparison to other African salaries. The lack of energy in the area of agricultural research is the result of an attitude problem; agriculture is low in prestige value.

Fee: We have to be careful not to always use the US as a model for agricultural policies. It's not always appropriate.

Soos: But for farmers pricing policies have more effect than prestige value. Overall, we need macro and sector level policies that are coordinated. Incentives have to exist at the micro level.

Bakker: Some farmers are refusing to produce because they receive money that is in essence valueless for their crop. In other countries farmers want crops that have a market or cash value. There must be different policies in different countries.

PROGRAMMATIC IMPLEMENTATION OF REGENERATIVE AGRICULTURE

James O. Morgan

PROGRAMMATIC IMPLEMENTATION OF REGENERATIVE AGRICULTURE

James O. Morgan

The implementation of the concepts of regenerative agriculture which is most consistent with its values may be characterized as a repeated process of learning, applying and testing. So the options for implementation present themselves more readily as ideas, challenges to understand and opportunities to test than as choices among various pre-designed packages.

"Regenerative agriculture" came forward as a concept in a situation--namely, North American agriculture in the early 1980's--which evidenced deep and widespread degeneration in the quality of life for the farmers, their profitability and the permanence of the biological environment in which they live and work. It had become increasingly evident that the trend must not only be stopped but reversed. One vital, and perhaps the most obvious, factor would be a radical reduction in the use of non-renewable resources--some applications of which have the additional, potential effect of polluting or destroying important parts of the ecosystem.

Similarities between the U.S. and some areas of the developing countries is obvious. The promise of high technology, high input agriculture has turned to disappointment and destruction in ecosystems more fragile and less resilient than the highly favorable climates and soils of the U. S. Corn Belt.

Other, even larger, areas have only heard of the promise of "modern" agriculture and either remained at their delicately balanced subsistence level of productivity or suffered extensive degeneration because of the pressure of increased population and destructively intense use whether occasioned by local growth in numbers, migration or flight from war and famine.

In North America, because of the prominence of high resource use and spiraling upward costs, inputs have received major, initial attention. Strategies for moving profitably and securely from high inputs to low inputs on U. S. farms are rapidly developing through collaborative efforts among farmers, the Regenerative Agriculture Association, the Rodale Research Center, researchers within the various systems and a growing number of farmer-to-farmer networks and forums. Interest and investigation is not limited to a specific network linked to the RAA or the RRC or any other single group. The current plight of U.S. agriculture has presented a challenge to the most creative talents among us to find answers that work and many are beginning to respond.

An analogous concern for "regeneration" has been voiced from every continent and almost every country--in Eastern and Western Europe, Sub-Saharan Africa and the Middle East, Central and South America, East and South Asia, Australia and the Pacific Islands. Fortunately, extensive degeneration has not always been the prerequisite to such interest and activity.

But it would be less than honest of us to represent what is now proposed as if we already have "the" answer or set of answers, the definitive package or system. We are all on a steep and rapid learning curve, seeing some of the exciting possibilities that certain technologies offer if they can be adapted across the ecological and cultural borders and also recognizing the immense challenge of finding workable and sufficient answers to the problems.

Remembering What We've Seen Before

As we put regenerative agriculture into action, at least eight observations from experience seem to be relevant to our present efforts in programming.

First, regenerative agriculture is not a single, universally applicable list of well-defined practices or technologies. It is a body of principles. For example, where lack of adequate rainfall is not a limiting factor, the regenerating contribution of leguminous cover crops to retention of moisture and organic matter, prevention of erosion, provision of biological nitrogen and weed control have been rather well-documented and accepted. (For example, see Bunch 1985) However, in marginal semi-arid and arid climates, where available moisture is a perennial concern, we have some exciting ideas and promising observations in hand, but how much do we really know with the certainty upon which we can confidently build a project? This does not rule out leguminous cover crops, but urges careful testing before making them a major thrust in a program for the arid and semi-arid areas.

Second, purity of concept is far less important than pragmatic effect. In the U.S, cutting the use of synthetic fertilizers and herbicides has contributed far more to successful transitions to lower-input systems than being able to claim total freedom from the use of all synthetic substances.

Third, regenerative agriculture (or any other agriculture, for that matter) is always set in a larger socio-economic context. The implementation of regenerative agriculture in programs appears again and again to be more of an art than a science. (See Bunch, 1982:vi; and Lele, 1979:255.)

Fourth, the list of identifiable obstacles to acceptance of practices and associated ideas is not infinite, but contains relatively few which are usually identifiable. There is an interesting parallel here with obstacles to the acceptance of practices in other sectors of development. (see Bogue, 1975:ix and 3).

Fifth, the benefits projected must be understood as capable of perception immediately in some cases, intermediately in other and only long-term in still others. For example, cutting back use of herbicides may be perceived as cutting input costs this year but not making a significant difference in groundwater quality for several years.

Sixth, the needs of people will consistently take precedence over the needs of the "new" production system when farmers have to make choices. In fact, there may well be a struggle over which is in control. (Korten and Carner in Korten and Klauss, 1984:201; and Korten, ibid.:300).

Seventh, we should at least consider that the "peasant mode of production" and the accompanying "economy of affection" may be quite different from our familiar, conventionally-defined economic and political categories such as "capitalist" or "socialist." The ties of tribe, kinship and community tradition are real and offer quite different microsystems which have often enabled peasant societies to survive major upheavals in their surrounding macrosystems. This consideration can have important, positive effects on program design (Hyden, 1983).

Eighth, most agricultural (and other) development program planning has given priority to external inputs in the design and packaging of activities and practices. How often we have experienced real anxiety over the critical role of timely external input delivery--whether chemicals, equipment or outside expertise. (For example, see DAI, 1975:19).

We expect that observations such as these would be shared by the majority of us as we look at the options and opportunities.

Affirming Some Common Goals

A principal reason for advocating that PVO and and bilateral programs hold great promise for implementing programs based on regenerative agriculture concepts and practices is the interesting overlap of goals as expressed in how we evaluate programs (or what claims all of us wish to make for our programs).

What are the values established by those proposing consideration of regenerative agriculture? Regenerative agriculture and related activities look for implementation that:

Emphasizes looking at capacities first; needs second. This means the capacities of people are believed in and built upon. Relief and ad hoc aid, by their nature, flow to needs rather than opportunities for change. Regenerative agriculture also looks first for the capacities of existing, traditional agricultural systems.

Looks to 'local' motivation and incentives for action and acceptance rather than 'foreign.' We do not assume aid is the cause or even carrier of improvement; it is at best a complement, an assistant, a stimulant. Is a cash crop for export earning foreign exchange a real incentive for a subsistance farmer?

Utilizes, cooperates with and adapts human and natural processes rather than dominating or overwhelming them. Measuring and carefully considering the effect on local capacities, social conventions, and economic processes are priorities. For example, how does introduction of a new practice or variety affect the forage available for the farmers' animals?

Encourages people to thrive with a sense of achievement and confidence in their own future. Actions must build on understanding local resources, their productive use and capacity for improvement. This includes the physical environment. For example, when mastering a new combination of crops in an interseeding system which increases yields gives confidence to try other "newer" ideas.

Proceeds most readily as a succession of overlapping activities rather than the simultaneous introduction of a complex package. Development history is replete with examples of the failure of complex, integrated packages (Owens and Shaw, 1975:153). A succession of related activities based on increasing capacities is more readily understood and carried out.

Expects the most lasting, widespread improvements to come from greater emphasis on 'internal' (local) than 'external' (outside) resources. Such improvements prove more durable and sustainable but also appear to be more capable of revitalization and regeneration across time.

Thrives with the growth of local equity share, for example, in resource ownership, credit and marketing channels rather than simple increase in income generated in a community or services provided. Such equity allows the strength of partnership rather than dependence on maintaining outside profitability and favor.

Perhaps a comparison of these principles or desired characteristics with PVO or AID expressed goals will suggest some initial bases for collaboration. There is more here than merely cutting back on inputs or supporting the processes of decentralization and localization.

For example, USAID wishes to look at its programs in the light of "critical issues." These include:

-- compatibility of a project with the host country environment

-- Demonstrated capabilities for development of human (and institutional) resources

-- The degree of sustainability built into the project in terms of continuity of both the process and the practices (USAID, 1984)

It is not surprising to find concern for effective technology transfer rising rapidly in the list of issues (USAID,1984).

PVOs value highly their ability to reach the poor and effect the development of basic human resources. They espouse a highly participatory process of planning to ensure compatibility with host communities and organizations. They continually refer to their concern with the process(es) as compared with merely "bottom-line" numbers. Their intended flexibility and experimentation along with a special ability to work with and strengthen local private institutions are also articles of PVO faith. (See InterAction,1985a and 1985b, and Tendler,1982).

Some of these values and goals are clearly matched or at least complementary. There is common ground from which to launch initial explorations.

Most importantly, the biases of regenerative agriculture lend strength to the opportunities for host collaborators to express their goals and values so the partnership we all want to bring about can really happen. Yes, there are and will be situations in which powers beyond our control will intervene and subvert even our best intentions and efforts. But let's see how far we can push the possibilities.

Identifying the Desired Ultimate Partners

Most of the concern for farmers and rural people in developing countries is expressed in terms of "helping the small farmer," "assisting the small-scale producer." Although the majority of farmers are "small" farmers in terms of the amount of land actually cultivated, this is not necessarily the critical factor let alone primary criterion for selecting a specific group of persons whom we hope will eventually benefit from a learning partnership with us. Almost every book or paper feels compelled to comment on or relate to the "small farmer."

However, our experience in the U.S. tells us that size of farm is not a primary determinant of either readiness to undertake a transition to lower inputs or successful passage to them (See RAAb,1985. Also see "Choosing the Strategies" below.)

A better correlation is obtained by using a chart which displays the relationships between various farming systems factors. On the following page, please note the eight factors expressed as a series of continua. Taken from Harwood,1983, it shows the majority of farmers represented by a band of values toward the left side of the chart--generally, the more "internal" and intensively managed end of each continuum.

More specific characterization of the "typical resource" farms helps us zero in on potential areas for program elements which would hold greatest promise to improve the system--and on the various factors which must be considered in dealing with any farm's production system.

We can also look at such a list of continua and relate potential areas of capacity improvement to any glaring deficiencies or needs.

The "typical resource" farmer and his sometimes called "peasant mode of production" is not managing a relatively small area of simple design and structure. He is farming a system with many balances and interrelationships which define his potential opportunities and risks.

This complexity extends to the social and economic context of his operation, described well as "the economy of affection." Affection, in this context, does not denote fond emotions. It refers to "a network of support, communications and interaction among structurally defined groups

FARMING SYSTEMS FACTOR RELATIONSHIPS

1 ECONOMIC/SOCIAL POLICIES FAVORING INCREASED PRODUCTION

Status quo	All-out

2 RURAL INFRASTRUCTURE

Poorly developed	Highly developed

3 PRODUCTION INPUTS (nutrients, pesticides, seeds)

Low use	Heavy use

4 MECHANIZATION/POWER

Animal ¼--------------

--------------½ Mechanical

None	Water Pump	Primary Tillage Transport	Threshing	Complete

5 FARM SIZE

Small	Large (corp./plantation)

6 LABOR USE (per unit area)

High	Low

7 PRODUCTION ENTERPRISE MIX

Highly integrated	Single (little interaction)

8 IMPORTANCE OF SELF-RELIANCE (in food/fibre production inputs)

High	Low

TARGET FARMS TYPICAL RESOURCE FARMS	HIGH RESOURCE FARMS

connected by blood, kin, community or other affinities, for example, religion" (Hyden,1983:8). This tightly bonded network has the strength to persist through major political and economic upheavals. A process similar to reviewing this chart was followed in targeting the farmers we thought would be the most receptive and most benefitted group in the U.S.--even though our process was at that time less precise and informed.

Note that the band marked on the chart represents the relative characteristics of the farm operation on which initial work could be focused.

Choosing the Strategies

Let's return briefly to current U.S. experience to see what we are learning about the process of developing strategies in cooperation with the farmers themselves.

We have found that as prices for commodity grains spiral lower and input costs higher, and as we see both farm income and land value falling while farm debt remains high and the strong U. S. dollar constrains foreign demand, more and more farmers are suffering deepening financial distress. With so many factors affecting their operations which are beyond their control, the farmers are looking for changes which they can initiate and which will help them survive in the short-term and hopefully allow them to once again have thriving operations.

So farmers are adopting two important strategies: (1) cut input costs and (2) look for additional crops to diversify their operations, especially in cash crops. Input costs can be cut primarily by lowering the inputs, but this must not be done unless it can be bottom-line profitable. And diversification of crops is heavily dependent on the availability of markets--which is most often a longer-term project in a given region.

As farmers test these strategies, they quickly learn that they must know much more about what is happening as they reduce fertilizer or pesticide use and begin to substitute green manures, new rotations and alternate tillage practices to provide needed fertility and control for weeds and insects. Their farming operations now become much more information- and management-intensive. Suddenly they are confronted with understanding a system rather than just attacking singular problems with purchase of new products.

Thus the first approach to the farmer is about cutting costs and improving his bottom line (the key factor for 3/4 of the farmers). Supporting information which deals with the important environmental and personal/family health and safety concerns is also included. These concerns are important to almost 3/4 of the farmers, too (RAA,1985b).

Then the farmer begins the transition, the size of operation proves to not be significant but "mind-set" does. A reliable in-depth study has been conducted by George Moriarity of Iowa, a farm consultant working with

175 farmers for more than 10 years. His data shows that farmers who become conscious about lowering inputs, and especially their cost, are the profitable farmers. Some focus more on making their money in the commodities markets and selling their crops "right" are more likely the big losers (Moriarity, 1985). However, we have learned that the farmer must be supported with relevant and timely information about managing his system and diversifying his operations on a continuing basis. For example, a book reporting research results and various trials by other farmers (RAA, 1985a).

Our bias at the start was to help farmers improve their systems with increasing reliance on knowing and using internal resources effectively and lessening dependence on purchased external inputs.

The chart on the following page further illustrates several simultaneous processes which we're observing with the farmers.

To provide information and support, we have combined on-station research with on-farm research, queried "transition" farmers by phone, mail and in person and solicited their participation in a farmer-to-farmer network of information exchange and help. We have held workshops, field days and special "debriefing" sessions to provide maximum feedback from their experiences. The important point here is not any specific technique employed; it is the fact that farmers and scientists are linked more closely with each other as well as with their own colleagues in the process of finding effective transition strategies and understanding the low-input systems as systems. There is enthusiasm in the exchanges and a sense of working toward important goals. The consequence is that the momentum of change is building.

This kind of strategy development and systems research parallels successful farming systems research and extension--and several PVO projects--at the international level. (See Harwood, 1979.)

From our point of view, we would suggest that "technology exchange" would be a more productive term for regenerative agriculture and FSRE-type programs than "technology transfer." The emerging improvements in the farmers' systems comes from a process of exchange as the trading of information cumulatively increases the knowledge of all the participants--researchers and extensionists as well as farmers. This approach to programming has also been called "the learning process approach" (Korten in Korten and Klauss, 1984). Such a process helps avoid the problems described by such observers of aid as Denis Goulet who point to the "high price" of some technology "transfers" (Goulet, 1977).

One critical factor is the capacity of the outside collaborators to form information networks and tap reliable sources of information on which they and the host collaborators can act together. Thus a capacity to turn around questions with appropriate answers at the lowest possible level can speed the interaction and increase confidence among the various parties involved. For more of the rationale and methodology, (see Haberern, 1985).

U. S. TRANSITION FARMER'S TYPICAL STRATEGY

CUT COSTS

- Cut fertilizer use
- Cut herbicides/insecticides

Note: Concerned about specific PRACTICES

Compensating with:
- Cultivation
- Rotations
- Different Tillage
- (Labor substituted for dollars)

↓

BEGIN SUBSTITUTES

- Use green manures
- Use cover crops

Note: Sees combinations of practices needed along with competence in TECHNOLOGY involved

↓

QUEST FOR KNOWLEDGE

- Attention to specific parts/relationships
- Search for understanding more than information

Note: With input costs lower, net income same or better, struggling with yield "reductions," and battling perceived weed and nutrient problems, wants to understand the SYSTEM(S).

↓

DIVERSIFY TO THRIVE

- Looking for added cash crops
- Spreading the risks
- Building his/her system

Note: Definite change in the amount and type of information required and desired.

As the farmer moves through these transitions, three of the farmer's concerns find answers and can help reinforce his decisions:

(1) Concern about personal/family health and safety.

(2) Concern for the environment (at least at the level of soil conservation--conservation of an important long-term resource)

(3) Concern about "lack of control" of his operation and dependency on others ('outsiders' and their resources) --such as product suppliers and bankers.

In general, experienced program people can define desired behavior changes in at least a general way early in the initiation of a project. However, one essential behavioral change (or hopefully, observed behavior) is the opening of participants' minds to working through to solutions as team effort rather than acting out expert/novice relationship.

One tantalizing question with which we're working at the moment is: how similar to the farming "learning process" approach would a gardening systems program be? (Either in the U.S. or Africa.) There are some intriguing differences as well as similarities so far. We're at the stage of beginning the widespread involvement of gardeners in the U.S. in verbalizing and filling in the rationale for a transition process and of observing the process in Africa.

Browsing Through the Catalogue

Regenerative agriculture, because of its site specific tuning of systems presents a "Sears Roebuck catalogue" of possibilities. It is tempting to fill pages with lists of known practices which could contribute to regeneration in a production system. There is a long list of technologies available and waiting for broader implemention and adaptation. Systems which have clearly regenerative characteristics and hold promise for further improvement have been identified in many parts of the world.

However, much of this information thus far is passed by word of mouth so far and the listing and following up with more detailed descriptions and clearer understanding is yet to be done. This, in itself, is a genuine programmatic opportunity which the Rodale Institute is considering.

Rather than lengthen this paper with the "laundry list" of sectoral possibilities, may I point you to papers such as the popular presentation "Enough Food," just published by the Rodale Institute (Rodale Institute, 1985); the paper in this series on regenerative technologies by Francis, Liebhardt, Barker and Kauffman (Francis, 1985); the forthcoming paper in the Journal of Alternative Agriculture by Harwood, Francis and Parr; and the long-awaited goldmine volume of African projects about to be released as part of the AID-backed study of PVOs in Africa (InterAction, 1985b).

The proceedings from the Tanzanian workshop of 1983 co-sponsored by Rodale, USAID, the Tanzanian Agricultural Research Organization and the government of Tanzania (Tanzania, 1983) contains technical data and suggested follow up plans. A recent report of the follow on two years later is appended to this paper.

At present, Rodale International as the international arm of Rodale Institute is exploring possibilities in Africa, Latin America and Asia with specific focus on the developing of information services and networks with a wide variety of collaborators. Focus on a carefully measured number of relationships and projects will allow attention to further testing of the ideas we have presented here. Responses and comments are welcomed and invited. This paper is intended to invite your participation in the ongoing discussions as well as inform.

Finding Other Collaborators

As we work in a collaborative mode which may call initially for a variety of expatriates as well as host country people, we do face the need to invest additional time and expense in bringing the all the people and plans and processes together in a workable way. If we want to develop the kinds of systems we have proposed, we must be certain that the benefits in the long term will more than justify the present added investment. We have already suggested a rostering of persons with expertise and genuine intent.

However, the past thirty years of PVO experiences say that the mix of collaborators (both expatriate and host country) is best developed in the field rather than in communications between various headquarters' locations and administrators. Arranged "marriages" do not have the best of records--at least in kinds of projects we're discussing here. This comes from personal observation and discussions in which I have heard similar comments from people in AID, host country national agencies, multilaterals and host community leaders.

Thus we are prepared to advocate that discussions in the field which begin the learning process are essential to effective collaboration in that field. While additional time may be consumed at this early point, surely the additional investment can be seen as speeding later processes and certainly avoiding costly re-starts and retrenchments due to hasty "elopements" which could have been thoughtful "courtships" or at least "trial" marriages. Pre-project investment in travel and exploration is a priority.

There is a wide range of potential collaborators available to each of us. USAID, the IBRD, other governmental and multilateral agencies can find ways to be responsive to others as well as include regenerative agriculture when proposing their own programs and agendas. And their agendas do change.

International PVOs and NGOs (including the churches and other religiously-oriented agencies) can be resilient, long-term partners for bringing new ideas to effective implementation across a period of years. This is especially true of those whose discretionary funding allows considerable flexibility in its allocation. The quality and commitment among their staff can be an exceptional and deep resource for building local capacities.

Indigenous PVOs and NGOs are the collaborators we all wish could be the strongest collaborators. But it requires exceptionally skillful and sensitive human relations to supply them with desperately needed operating funds and support for staff without making them the handmaids of the expatriates.

Tougher, but even more exciting when it really happens, is the direct, open collaboration with a local community itself. It is so easy to overwhelm with the comparative advantage of more abundant financial and more experienced organizational skills! And major agencies not usually capable of operating at this level.

The private sector as represented in business and the cooperative involvement as well as the grantmaking foundations should be added along with the important research institutions--whether part of the Consultative Group, universities, or national research programs.

All of these potential collaborators have important roles to play. Yet the final "mix" must be on the basis of positive contribution to the team effort and not just availability or the prestige of association. Easy to say, but often tough to do.

Repeating the Process

Collaboration, localization, multiple adaptation, exchanges of ideas and technologies, persistence in relationships, and commitment to shared goals are all important parts of the explorations under way.

Regenerative agriculture is not intended as simply a revised vocabulary list or new dialect of agricultural development jargon. If this is what happens and "RA" becomes the latest buzz word its basic purpose of giving alternative options new opportunities will surely fail and we will go searching for ways to regenerate our goals and commitments.

We believe that regenerative agriculture is more than a new set of terms or different color of filter for ideas. It offers the practical opportunity to reconfigure and improve existing systems as well as develop new ones in which the capacities of people, their land and their environment are not just regenerated; they themselves become forces for regeneration of their communities and quality of life.

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Additional points made in the presentation:

None made.

Key discussion in depth:

Mukusya: Briefly, I was born in Kenya, raised on the farm and where I come from life is rather difficult. But I had worked outside my own community for about ten years before I came back home.

The problems that we face in my own community and in my country are a matter of life or death. You have to make sure you survive. The question isn't whether to be a good person, but to find a way of surviving. To survive, you are to have things that can make life easier to live in. We are trying to tackle several problems. One is drought; the other is poor land management. Soil erosion, water for crops and livestock and water storage for our people.

Soil conservation is done communally. People work on terracing land to control soil erosion to try to control the flow of water for later use.

Conduit ditches are being used to conserve the remaining soil, even though the topsoil is gone and isn't good for growing crops.

Terraced land can be productive if the people take care of the soil. Terraced land conserves enough moisture to grow crops and will help the African people to survive.

Water conservation - our streams are just big gullies. We are trying to put barges across the river to store water by the barges. Those other things we call subservice dams are made of stones.

The process of making these subservice dams is making a frame made of timber and stuff it with stones. The process may take several years or several months according to the amount of resources that you have available.

At the bottom of the river there is a pipe where people draw water from. The flow of the water through the sun keeps it clean.

After putting walls and barges across our streams, you can grow vegetables and establish nurseries.

During 1983 when there were only three days of rain, the only crop that materialized was the amaranth. The leaves are sued for vegetables in my community.

In my community, we feel it is not the external force that will give solutions, but the people.

We are trying to experiment other systems. My grandfather didn't use rows for planting crops. What I'm doing is planting randomly and mass planting - beans, peas and maize - and they are harvested at separate times. It is an old system which is regarded in the extension service as intercropping farming, but since it worked we have decided to go back to it. Since the new stores have come, we have a lot of problems. We must do clean farming, spray crops, we have a month to buy the chemicals, we don't know what to do after the fertilizer is used. We were raised and survived the grandfather's system, why not return to it.

Rodale: What about the yields in your trial of interplanting and interseeding?

Mukusya: When you intercrop maize and beans, the maize generally does better than the beans. When intercropping cowpeas, pigeonpeas and maize, the pigeonpeas do better than the maize and the cowpeas the worst.

Rodale: What about the dimensions of your program in terms of people?

Mukusya: The village of Utooni is a community of 10,000 people. By the year 1988, we expect to cover at least 64,000 families. The present budget is 500,000 Kenya Shillings (that's about 30-35,000 U.S. dollars). That will include the truck that we use and seminars and trips for expeditions to see what other farmers are doing in other parts of the country.

Bakker: I'm very interested in communal land that is worked together. In my experience people in cooperatives try to do as little as possible and then there are fights over the spoils, if there are any. Is it a tradition in your community of communal working of the land?

Mukusya: The system of working together in my tribe dates back to when Christianity came. There is a communal plot in every village and there are thousands of small groups working together. We have individual plots where we practice agriculture. But since we cannot do all the things we want to in everybody's home, we have an open land, we all plant it and we share the results of what we've grown, from the fields to the communal store.

Jordan: We hear that research simply doesn't reach people in communities and villages like yours. Kenya, perhaps, as an African country, has one of the best research systems; I think it would certainly rate high. What's your evaluation of Kenya's research as it serves you in your community? Is it good, bad, useless, excellent?

Mukusya: The work done in the research stations is very good and some benefit has come out of it, but it needs someone else to take it from the station right to the people where they do the farming which is now the question of the extension service which is not efficient.

Jordan: We find that in many projects it's very, very difficult to get communities to work on water and land conservation projects because of the long-term payoff and also the inputs that often time are labor as well as monetary, costly, and I'm very curious as to the mechanism that's used in the Kenya context to induce the small scale farmer to invest the time and the labor and developing the structures such as the dams, the catchments, the terracing, the tie ridges that may often not belong to any individual but may belong to the community.

Mukusya: When they decided to do some soil conservation in my own district they thought it was easier to pay people to do the digging of terraces and conservation ditches. That has happened for some long periods and at the end it was found paying people to do the work that benefited them was not the solution. And now to change their minds from the money you'd given them to free work became a joke.

Individual organizations say like the Mission council of Kenya will do a lot in the field to tell people to terrace their own land and all they need is to be sure how to measure the ditches and then you send someone who puts frames and puts pegs around and then they will make it. But when it becomes a question of the Minister of Agriculture to come close to that people tend to remember what money they were promised sometimes and they tend to say "we might do it if you pay us" and I think if we take time to allow the people we work with right in the villages where the problem is, that could be possible and the people could benefit and soil conservation could be tackled easily.

Morgan: One point, Joshua, that I think I can observe as having visited; when you were building that first subsurface dam across the stream and your experience through four years of drought where you had maybe a couple days of rain per year was that the subsurface dam that the water provided and held in the sand - it never went dry in four years. What effect did that have on building other subsurface dams?

Mukusya: The effect is that today if you talk of someone having 300 bags of cement you will have about 60 groups looking for that because everybody's out looking for the little they can get to put subsurface dams across their streams so that they can have water that can go through such hard times like we went the last four years.

Haberern: Joshua, I'd like to return to the question that Vern had concerning research on station - who's giving direction for that research, what type of research is being done there, is the direction coming externally or is it coming from your people?

Mukusya: That is from the top part of the planning section, it is done from the top.

Summary of other discussion:

Morgan: Joshua, what is the relationship between farmers and extension?

Mukusya: For traditional reasons, the people tend to be away from extension.

Barry: If the local extension officer isn't effective -- what is wrong, is it his background or education? Why doesn't the system work?

Mukusya: If you talk of being a forester -- you must have seeds to plant. If you don't do what you say, people are not going to listen.

Kramer: Back to the question the perceived value of long term benefits. Farmers in developing countries can plan for the long term. Farmers do understand and will invest in five year plans.

Wheeler: You can't try to swim upstream against economic trade. There are strong forces there and you would be fighting the system.

Small farmers are sensitive to export crops. Drugs show they definitely are sensitive to them. Cash flow crops are important.

Morgan: Small farmers are not saying that they're not open to cash crops. Emphasis has been on the neglect of cash crops.

Erickson: The role of women in agriculture in Africa is important. They produce 75% of food. We need to talk more about the role of women in agriculture.

Mukusya: That is true. Women do almost everything. Men go and look for money in town. They leave their families to do all the work such as collecting water, collecting firewood, growing crops.

No one takes a serious look at women. The men own the land, whereas women can't. The question of women getting some of the burden lifted from them is unclear. They need to have water and wood near them. That would take a great deal of money.

The children go from school to gathering firewood in the bush. There is no time for reading or other leisure activities. They go straight to bed -- tired.

In villages it is very different than it is in Nairobi. Foreigners don't see the bad side. Women should be heads of community because most of the men are here only once a month or so.

Ferguson: FAO has now stated that 17 countries in Africa must increase production per unit area. The need for more intensive means of production must be our focus.

THE REGENERATION OF AFRICA
Resources, Needs, and Capacities: Inventories for Mobilization

Medard Gabel

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INTRODUCTION

Problematique

Africa's problems are legion: a 15 year drought;[1] environmental degeneration that includes mammoth soil erosion -- over a billion tons per year in Ethiopia alone[2] -- lost soil organic matter and depletion of soil nutrients,[3] deterioration of grasslands due to overgrazing of livestock,[4] deforestation due to firewood needs,[5] deterioration of irrigation systems[6] and increasing desertification;[7] unemployment;[8] lack of education;[9] overpopulation;[10] low food grain and water availability;[11] declining exports;[12] a $170 billion foreign debt;[13] political strife;[14] decreasing per-capita income and food production;[15] lack of adequate infrastructure;[16] and the grim horror of all these failures compounded into their most tragic human dimension -- famine. In just Ethiopia, more than a million people may have died of starvation in 1984 alone.[17] More than 20 million are threatened by starvation on the entire continent, while as many as 100 million are malnourished.[18]

Past Methods of Solving Problems

Old ways are not working. Present models for economic development or agricultural production are inappropriate to Africa's needs, capacities and resources. The "green revolution", which worked well in the United States and a few other areas of the world, is turning into the grim revolution in parts of Africa. Accelerated agricultural production through high inputs breaks down when countries without the necessary capital resources can no longer buy the machinery, energy, fertilizer, pesticides, seeds and infrastructure needed to put together such a food-production system.[19]

Lack of capital to purchase inputs has derailed, or slowed to a near standstill, the green revolution in one African country after another. As it turns out, this could be a propitious happening -- if capital were unlimited and the express train went on down the track of imitating the North American food system, hundreds of millions of people would be left unemployed. If Africa produced all its food with just 2% of its population, as the United States does, over 400 million people would be without employment.[20]

Contextual Strengths

As dismal as all the above is, Africa is a strong continent with vast resources and capacities. Over 400 million people are well fed. Farmers, manufacturers and businesses throughout Africa are successfully meeting the challenges of new countries and their young populations, with their attendant needs, expectations, hopes and capabilities. Literacy levels areas, it is as high as 70-80%.[21] Health care has improved dramatically so that infant mortality is down one-third and average life expectancy is up 20% -- from 39 years to 47.[22]

Need for New Approach

To meet the needs and challenges of Africa, as well as to creatively tap its capacities and resources in affordable ways, something new is needed.

A process of development that is based on the concepts of "regeneration" is one possibility. Regeneration is based on a hierarchy of self-reliance which starts with people and the soil they depend on for their food. It seeks to increase self-reliance through the knowledge a knowledge and use of local resources, needs and capacities. It seeks to combine the frugality of local resource utilization with the extravagance of local vision that is in tune with the capabilities and needs of the people residing there.[23]

REGENERATION

Definition

Regeneration, in its most general sense, means "to restore to a previous condition: to renew; to improve."[24] Biologically, it refers to "the replacement by an organism of parts of the body which have been lost or severely injured."[25] and, "the replacement of lost or injured tissue permitted by the ability of some cells to de-differentiate and develop in a new way."[26] Environmentally, regeneration refers to a process of ecosystem healing that leads in the direction of ever increasing diversity and vitality. Economically, regeneration refers to a process of economic development that heals the basic wounds of a development society -- the unmet basic human needs -- through an increased self-reliance -- which is brought about by the ability of a local economy to de-specialize itself and use its local resources to produce a more diverse set of products for the local market -- thereby increasing its diversity and vitality. What this means for Africa is that the successful application of regenerative concepts and tools could reverse widespread environmental degeneration and help in economic recovery and growth.

Regeneration is the restoring of the original vitality that a system once had. It is a subset of "generation" -- which is the creation of vitality in a system. Because of its problems of environmental and economic degeneration, economic underdevelopment and unmet human needs, Africa is in need of both regeneration and generation. Both processes can be started and furthered by the concepts and tools of regeneration.

Need

Because regeneration relies on internal resources and self-reliance rather than the importation of expensive external resources from foreign countries, it is an economic improvement strategy that is ideally suited to the limits and constraints of today's world. Given the debt load of Africa and the reluctance of many developed countries to give or loan further resources, a as well as the current trade arrangements between Africa and most of the developed world, which severely limit Africa's ability to generate foreign exchange,[27] it is becoming increasingly clear that self-reliant or regenerative development is the only path available that can:

1) produce the needed results
2) with the limited resources available
3) while building capacities for further growth, and
4) following the direction of local vision.

Africa needs the concept of regeneration. And even more, Africa needs the tools that can bring regeneration about. (A "tool of regeneration" is a technique, process, organizational structure, or information collection and synthesis method, that when skillfully applied, can set in motion the process of regeneration. See "Tools" section.)

How it Works

The concept of regeneration works on many levels. It works at the level of agricultural production through the processes of biological structuring, nutrient cycling, local nitrogen fixation and biological pest control (detailed in other parts of this report) that synergistically reduce soil erosion and build fertility, while maintaining high yields with low purchased inputs (illustration 1).[28]

At the level of the local marketing economy, regeneration can work through the processes of local distribution structures, recycling of wastes, renewable energy use and import substitution that synergetically provides increased employment, keeps more monetary resources within the community, enriches the natural resource base and increases the health of the population (illustration 1).

A key ingredient at both levels is control and direction. Just as the farmer has to have the information he or she needs to control, maintain and direct the regeneration of the farm production economy -- information about soils, climate, fertility, crops, animals, pests, rotations, interplanting, compost, input costs, management strategies and tactics, etc. -- the people involved in the local marketing economy need the information that is necessary to control, maintain and direct the regeneration of the local economy. Information on manufacturing outputs and capabilities, resources used and availability, imports, markets, etc., would be important to local entrepreneurs and decision makers for locating opportunities. Both levels of regeneration are information intensive.

At the level of damaged soils (illustration 2, Level 1), regeneration works by restoring the microorganisms that used to be in the soil, restoring the tilth and organic matter of the soil -- along with its water retention capabilities -- and the nitrogen, phosphate, potash availability in the soil.[29]

Regeneration works at the level of the crops that grow in the soils (Level 2) by restoring the insect balance that has been destroyed -- thereby helping to restore the capacity of the ecosystem for biological pest control.[30] Also at this level, regeneration works for the increased vitality of crop production systems by diversifying the crops and animals produced.[31]

Regeneration works at the level of the land (Level 3A) by stopping the advancement of desertification and the reversing of that process. Regeneration can work to decrease the size of deserts by increasing the eventual spread of fertile productive lands into former desert areas.

Regeneration works at the level of the family (Level 3B) and its improved nutritional status by supplying the family with a more diverse set of crops for home consumption. Additional revenues from a more diverse crop and marketing structure also brings added security to the family.

Regeneration works at the entrepreneurial level (3C) by revitalizing the climate for enterprise growth through such things as providing information on markets, resources and business opportunities, as well as helping to create increased credit and managerial support for small businesses.

Regeneration works at the local market place level (Level 4) by providing additional outlets for local farm products and manufactured goods.[32] This in turn can generate more jobs and add revenues to the local economy.

Because the key to regeneration is information and knowledge, not energy, materials or capital, it is of necessity people centered. To bring about regeneration at the soil level, information needs to be collected, synthesized and communicated to the farmer who will be using the information. In the same way, the local marketing economy or village needs information about the needs, resources and capacities of local markets, production capabilities, resource use, natural resources base, human resources, imports into the region, available technology, energy, shelter, health care and capital.

HOW TO DO IT:

<u>Self-Reliance Operationalized</u>

It has been said for many years by numerous experts in the fields of economic development, food production, foreign assistance and policy analysis that the solution for the world's food problem lies in the direction of increasing the self-reliance of food-short countries.[33] The entire continent of Africa is certainly no exception to this common-sense wisdom.

What has not been said as often or as loudly is that the path to increased national self-reliance is self-reliance within each country at the regional, town, village, family and farm level (illustration 3). What needs to also be said is that any process of increasing self-reliance needs to begin with a shared understanding of what self-reliance _is_, in operational terms, at the soil, farm family, village, town, regional and national levels. Self-reliance needs to be made real, tangible and measurable; it has to become more than mere sloganeering and arm waving.

To become operational, the concept of self-reliance has to move from the qualitive to the quantitative and from a "concept" to a goal. It needs to be in a context of development that is in tune with the needs, capacities and resources of a village, region or country. For this to happen, the area in question needs to _know_ its needs, capacities and resources. Self-reliant development -- regenerative development -- therefore, begins with the inventory of what an area has to work with -- just as any work on the regeneration of a farm begins with a thorough understanding of what resources are available there.

One of the tools of regeneration -- the Vitality Index -- can be used to determine an area's potential for self-reliance and its progress towards that goal (see Vitality Index, p. 15). Other tools, in similar ways determine a local area's resources, needs and capacities.

It is no accident that the word invent is at the core of inventory. It is through inventory that resources, needs and capacities are "invented." Without the information of their existence, resources, capacities or needs do not, in any practical sense, exist. By inventorying a region or country's resources, needs and capacities together, as part of one systematic process, we create new connections, patterns and opportunities.

With a comprehensive resource, need and capacity inventory, decision makers -- entrepreneurs, farmers, local and national government officials and economic assistance agencies -- will be able to see opportunities for increasing regional self-reliance through increased utilization of local resources to meet local needs.

Local Mobilization

A regenerative development process would need mobilization at the village level and be organized, with appropriate outside assistance, by and for local people. A Peace Corps, OxFam, Save-the-Children, or other PVO village-level type of effort would be the model, not the large scale project-oriented approach that characterizes most aid to Africa today. Throwing money at the problem will not work -- not only is there little money left to throw, but the basis of any regenerative strategy has to be people, not capital. And because it is people-based, it has to be decentralized, village-centered. The centralization that often comes with capital intensive projects will break down in a regenerative approach. Additional capital is necessary, but it needs to be divided into smaller bits: it needs to be more information intensive than it has been.

Training Regenerative Commandoes

Training to do the following inventories, searches and index would emphasize the process of involving the community in the use of all these tools. Forms for data collection (including computer software, where appropriate) and display to the village need to be provided to insure accuracy, completeness, integration and access.

A local group, after training, could use versions of the following tools that were appropriate to their area and its level of economic development to determine needs and locate the resources and capacities they will need to begin the process of regeneration. Such a group of "Regenerative Commandoes" would be a powerful force for peaceful local change and development.

Needs Inventory

A Needs Inventory determines the basic human needs of a given zone. Basic requirements for food, water, shelter, education, energy, health care, transportation, and jobs are determined and then translated into various units of measurement that are based on local resources -- such as, the amount of land required to meet local food needs, number of shelters needed to house everyone adequately, annual supply of building materials needed, number of teachers or schools needed to bring everyone up to a level of community defined literacy, etc.

Human Capacity Inventory

A Human Capacity Inventory determines the capacity of the given zone to provide for itself. The Human Capacity Inventory is distinguished from other inventories of a zone in that it is focused on human resources. Skills in such areas as carpentry, plumbing, carving, engine repair, farming, child care, health care, education, entertainment, etc. -- any unique skill that a person has -- would be documented and then compared/matched with the results of the Needs Inventory and other searches.

Local Economy Inventory

The Local Economy Inventory serves to match local manufacturers and businesses with local suppliers in order to replace costly imports coming into a region. It comprehensively surveys all enterprises and institutions in a region. It covers both primary and secondary material inputs as well as waste products that may have potential economic value.

Included in this inventory are manufacturers, service companies, nonprofit organizations, and local governmental agencies. This inventory has the potential for significantly increasing the vitality of a local economy. It will put local product and supply information at the tips of a business person's fingers. A similar effort in Oregon, USA, has increased local sales by millions of dollars. Their "Buy Oregon" program has matched up local or regional businesses (that were previously buying goods or services from hundreds of miles away) with suppliers virtually in their own backyards.[34] This has led to steady improvement in the economic health of local businesses and residents alike. The Local Economy Inventory reaches institutional purchasers as well as explores how wealth could be generated from materials previously regarded as waste. This inventory can translate into lower costs through import-substitution, and into new enterprise creation through a dynamic awareness of the local economy's needs, capacities and resources.

Natural Resource Inventory

This is a comprehensive accounting of natural resources in an area or zone. The inventory would include land, minerals, forests, water and energy resources, and any unusual or economically important flora and fauna. The inventory provides a list of materials which could substitute for imports from outside the area, and which could provide raw materials for further new economic opportunities.

Import/Export Inventory

This is an examination of all imports and exports for an area, from food to fertilizers, energy and appliances. The purpose is to help locate those items which have the highest potential to be produced locally with local resources.

AgMarket Search

Each year, bulk food buyers in a given area purchase thousands of pounds of meat, fruit, vegetables, grains, and dairy products to supply the area's schools, cafeterias, hospitals, and restaurants. Frequently, these foods are shipped from farms hundreds, even thousands, of miles away, even though farmers in the area can often produce the same commodities. AgMarket Search tabulates the amount of regionally-grown farm products that bulk food buyers in the area would be willing to purchase. These would be commodities that are now purchased from outside the region but which could be grown locally. Given that some regions import large percentages of their food (up to 90 percent in some areas) at annual dollar losses in the millions -- any increase in the amount of food produced and marketed within a region will cut down on this dollar drain, keep more farmers in business, and enrich the entire area.

A given community would reap many benefits from AgMarket Search. First, the regional agricultural community would be strengthened by learning about new, nearby, stable markets. A more diverse market and more diverse crop production system would reduce risks taken by local farmers. Residents would benefit from fresher and thereby more nutritious foodstuffs. Food costs could be lower due to the elimination of expensive transportation costs. Finally, there could be new job and business opportunities in providing supplies for increased farmwork and in the distributing and processing of foods locally. An AgMarket Search done in a small area in Pennsylvania, USA, revealed an untapped $43 million market for locally grown foods.[35]

Farmer Search

Farmer Search is an inventory of all food producers in an area. It would determine the quantities of the different commodities produced and how much is available for local purchase. The end result would be a directory of producers for a region which would aid consumers as well as bulk buyers in purchasing local foodstuffs and supporting local food production.

Energy Search

An Energy Market Search will locate and identify the market for services and products which conserve and generate energy. This search would consist of two components -- the residential market and the industrial/business/commercial market. Questions would be asked about the need for new, more efficient cooking stoves, water heaters, heating units, solar collectors, solar water heaters, passive solar remodelings, solar greenhouses, etc.

The Commercial Energy Market Search would ask similar questions of business and industry with the addition of options such as waste heat recovery and use, water recycling, co-generation units, etc.

Healthcare Search

The Healthcare Search would survey a community and ask "When you have a health problem, who among your friends and neighbors would you ask for help before deciding you needed to consult a professional health worker?" The survey will locate the people in the community who were mentioned most often as "natural helpers" of the native healers in the community. These people will then be asked about their needs -- what kind of help they felt was necessary to aid them in dealing with the healing questions their friends and neighbors presented to them.[36]

Vitality Index

The Vitality Index measures the degree to which a community could expand its local markets and its resource and business capacities. It does this by establishing the extent to which a region provides for its own food, housing, energy and other vital necessities. These figures are then compared to what residents in the established zone could actually provide for themselves given the limits of their resource base and present day appropriate technology. The Index's results are a guide for business leaders, entrepreneurs or governmental officials on exactly where new business opportunities exist for meeting local market needs with local resources.

The Vitality Index is intended to point out opportunities for reaching the highest possible level of economic self-reliance. The principal benefit of the Vitality Index, therefore, is that it acts as a comprehensive, yet succinct, quantitative summary of the local or regional economy. This summary will be a touchstone for identifying specific areas in which enterprises can grow. As a measure of local economic health, it could be calculated on a periodic basis. Economic improvement and greater self-reliance would witness a rise in this index over time.

Process of Regeneration

Local regenerative mobilization needs to be in the context of a national regenerative development strategy. Some of the processes and tools called for at the local level could be of use at regional and national levels. Resource, need and capacity assessments of region, nation and continent need to be made to help identify country or continent-wide strategic opportunities for regenerative development.

From a national or international aid perspective, a regenerative development process could be set in motion through a series of steps, starting with the selection of two to four test sites and progressively building out from the base of those experiments. The following broad brush stroke steps are for illustrative purposes only.

Step 1: Transfer the concepts, goals, methods and control of the regeneration process to local residents. Their insights and understandings need to control the direction of the zone's regeneration. This would involve a series of workshops and intensive training sessions followed by the formation of a core group of local residents who would form a regenerative zone development task force. This task force would undertake the following activities:

Step 2: Determine the imports into the zone. This would involve an inventory of the food, energy, materials, water and capital inflow and outflow from the zone. Working with zone residents, use and refine the tools of regeneration in these zones to more accurately match the uniqueness of Africa.

Step 3: Determine the resource needs of the region for food, energy, materials, capital.

Step 4: Determine the natural and technological resources of the zone. This would involve the use of various regeneration tools -- Local Economy Inventory, Natural Resource Inventory, etc. to assess the land, water, crops, forest, etc. and the technological capabilities of the zone. Derive from the use of these tools, the needs, resources, capacities and opportunities of the various zones.

Step 5: Choose the specific technologies that could use local resources to produce products and/or services than can substitute for imports.

Working with zone residents, determine from the data the areas that have the highest potential for rapid economic development.

Step 6: Identify and bring together resource people (both local and from other countries) who can assist in the transfer of regenerative technology. Begin implementation process for economic development projects that residents have devised from the data gathered in the above steps.

Step 7: Nurture on-going regeneration process through continued support, networking, new venture incubation, etc. Re-do Vitality Index to evaluate and monitor change.

After the preliminary tests of two to four zones, it may be judged prudent to begin additional regeneration zones in other parts of Africa. In addition, the interrelation of different zones needs to be then explored and developed.

FOOTNOTES

1. Richard H. Kerr, "Fifteen Years of African Drought," Science (22 March 1985): 1453. See also, Lee Lescaze, "Burkina Faso Lives on Death's Doorstep As Sahel Drought Enters Its 15th Year," The Wall Street Journal (21 May 1985). p. 34.

2. U.S. Agency for International Development, "Fiscal Year 1980 Budget Proposal for Ethiopia," Washington, D.C., 1978.

3. The Food Producers Who Go Hungry," UNICEF News, Issue 120 (Summer 1984), p. 5.

4. Janet Raloff, "Africa's Famine: The Human Dimension, Socioeconomic Factors May Play As Big A Role in Africa's Crisis As Does The Seventeen-Year Drought," Science News, Vol 127, No. 19 (11 May 1985), p. 299.

5. International Bank For Reconstruction and Development, Accelerated Development in Sub-Saharan Africa, An Agenda For Action, (1981), p. 100.

6. Ibid, p. 77. See also, Paula Park and Michael Cross, "The Village That Fought Back," New Scientist (4 April 1985), p. 41.

7. p. 5. See also, Victoria Brittain, "A Way of Life Lost Forever," UNICEF News Issue 120 (Summer 1984), p. 10.

8. World Bank Development Yearbook 1984.

9. According to the World Bank, adult illiteracy in Sub-Saharan Africa in 1976 was 772%. Compare this to 64% adult illiteracy in South Asia, 48% average in all developing countries, and 1% in all industrialized countries. International Bank for Reconstruction and Development, p. 3.

10. Fred T. Sai, "The Population Factor in Africa's Development Dilemma," Science, Vol. 226 (16 November 1984), p. 802.

11. Michael Cross, "Waiting For a Green Revolution," New Scientist, Vol. 105 (4 April 1985), p. 37.

12. "United Nations Declaration on the Critical Economic Situation in Africa," as excerpted in United Nations Office for Emergency Operations in Africa, Africa Emergency Report Vol. 1, No. 1 (April-May 1985), p. 10.

13. Lester R. Brown and Edward C. Wolf, "Reversing Africa's Decline," World Watch Institute (June 1985), p. 71.

14. International Bank for Reconstruction and Development, p. 10.

15. Helen C. Low, "Africa's Struggle For Sustained Development," Care Briefs on Development Issues No. 5 (Washington: Care, 1985).

16. International Bank for Reconstruction and Development, p. 105.

17. Low.

18. Ibid.

19. Cross, p. 37.

20. 2% of 560 million = 11,200,000 or 548,800,000 people unemployed.

21. Low.

22. Ibid.

23. Medard Gabel, et. al., Regenerating America: Meeting the Challenge of Building Local Economies (Emmaus: Rodale Press, Inc. 1985). Concept Papers of The Regeneration project.

24. Webster's New Collegiate Dictionary, Marion Webster, Springfield, Mass.

25. Encyclopedia of Science and Technology, 5th ed. s.v. "Regeneration."

26. Charles Levy, Elements of Biology.

27. International Bank for Reconstruction and Development, p. 18.

28. Charles A. Francis and Richard R. Harwood, Enough Food (Emmaus: Rodale Institute, 1983).

29. Ibid.

30. Ibid.

31. Ibid.

32. Helene Hollander, "The Lehigh Valley Food System: Opportunities for Economic Growth" (Emmaus: Rodale Press, Inc. 1983).

33. See, for instance, Karl Borgin and Kathleen Corbett, The Destruction of a Continent, Africa and International Aid (New York: Harcourt, Brace, Jovanovich, 1982), p. 182; Lester R. Brown and Edward C. Wolf, Reversing Africa's Decline (Washington, D.C.: Orton, 1985, p. 66; Food and Agriculture Organization of the United Nations, World Food Report, 1984 (Rome: FAO, 1984, p. 46; Henry F. Jackson, "The African Crisis: Drought and Debt," Foreign Affairs, Vol. 63, No. 5 (Summer 1985), p. 1091; John Madelev, "Does Economic Development Feed People?" The Ecologist, Vol. 15, No. 112 (1985), p. 36; M. Peter McPherson, "Meeting the Challenge of Africa," Horizons, Vol. 4, No. 2 (Spring 1985) p. 21; Organization of African Unity, "The Lagos Plan

of Action for the Implementation of the Monrovia Strategy for the Economic Development of Africa," adopted by the Second Extraordinary Assembly of the OAU Heads of State and Government, Devoted to Economic Matters (Lagos, Nigeria, p. 28-29, April 1980), as cited in International Bank for Reconstruction and Development, p. 118; and Atul Wad "Science, Technology and Industrialization in Africa," Third World Quarterly, Vol. 6, No. 2 (April 1984), p. 327.

34. The Regeneration Project, "Buy Oregon Adds $2 Million to County Economy," Regeneration, Vol. 1, No. 2 (Summer 1985), p. 6. For information about Chicago's "Buy Local" plan see Medard Gabel, et. al. "Local Regeneration, Examples to Build On," (Emmaus: Rodale Press, Inc., 1985), p. 17.

35. The Cornucopia Project, "AgMarket Search Summary Report" (Emmaus: Regenerative Agriculture Association

Key discussion in depth:

Diallo: I'm originally from West Africa. I'd like to ask Joshua a question on research: Do you know of any crop in Kenya in your community or in your region that has been negelected by either the research organizations in Kenya or the international research and the reason I'm saying that because in West Africa we have identified some crops that have long been neglected by the European, the French in the case of Guinea, my home country, research community and one of these crops is a legume crop called Bambara Ground Nut. The University of Maryland Eastern Shore is now working on research on Bambara Ground Nut because they have discovered it is a crop that is very rich in protein, 16% protein content. There is another crop, a cereal this time, called in French, funio, is Digitacia excellis, the scientific name. So, do you know of any crop in Kenya that deserves more attention in terms of research?

Mukusya: At the present, no, but the plant that used not to be taken seriously which is now being taken care of is to be dolica. Dolica is one of the legumes we have had for many years and which used to grow in the hills which had not been taken care of but presently now is being handled.

Hinojosa: Are there any crops that are growing in your community that have come out of the central research station that have benefited you?

Mukusya: Yes, we have a very drought resistant maize variety which we call Katumani which is part of the research station.

Swanberg: What I think is interesting here is that AID claims a real success story in Kenya with Kitale maize. Kitale maize was developed in Western Kenya under very high fertility soil and high rainfall and we claim it has had tremendous adoption throughout Kenya. I don't think it works for the drought stricken areas. What was developed at Katumani research station was the Katumani maize, a short season maize, not for high yield but for tolerance within a short season and it went like wild fire. I think eight years our district data showed about 80% adoption whereas our hybrids in Iowa take 20 years to get adopted. So it's a real success story that really took over there because it was the technology that fit exactly to the limitations and constraints of the region.

Bittner: I wanted to ask Joshua if people in your community are involved with research planning and if so how are they involved with research planning.

Mukusya: We are not involved in research planning.

Bittner: Do you perceive or do the people in your community perceive a need to communicate some of your results with research on your plans for helping lessen the drought, and death in the community?

Mukusya: What we are aiming at and what we do is we have groups coming all over the place. You come and see what we are doing, you like what we are doing and see whether you can try it on your own area. But we don't say this is the right thing you should do.

Dover: The comment is when you talk about information intensity I couldn't agree more. What I have been hearing yesterday and today and the discussion about information intensity is the tendency to think in terms of collection. In managing eco-systems and also in terms of managing economies there is also a need for another kind of information which is for lack of a better term based on monitoring. In system terminology this is known as shortening feedback loops and generally our systems dogma is that the shortening feedback loops tend to result in greater stability of the system. I would just want to encourage to think in terms of that kind of information intensity as well as what I might call marketable information intensity.

Soos: We in the development business have a plan and to look at all the complexities of everything and then try to follow them through and make sure that it gets done. It is a good propensity because it is a mark of thoroughness, but it also has its pitfalls. One of the things that we have to worry about with information like this is not to try to put ourselves in a position of being responsible for seeing it through. By trying to take that responsibility we have mucked up many a good agricultural opportunity and many a good industrial opportunity. The worst small business programs that I have seen are those that are over planned. We need to build on people's capabilities allow them to take information and do with it what they can and help them to do with it a little bit better than they might otherwise, or best just leave them alone in some cases. Along with information intensity in sort of a developing environment, I think we need to add the counterpart to that which is enhancing people's capacity to take advantage of that. Not doing it for them.

Morgan: What experience do we have among us this morning or what processes have we've seen in terms of looking internally to a farming or rural area for additional ability to provide other crops besides the staple food crops to meet local needs in a market type way? What processes have we seen or could we envision that would begin to look in those same areas for opportunities either for manufacture, distribution or whatever it is that is some kind of material or production or service within a local rural community in a developing country.

Barry: One of the problems that I've experienced in Africa is that they have a stable diet which is what they are used to eating and it is very difficult to introduce a new food stuff to their diet. You will find people, like in Kenya especially just one example there is the fact that wheat grows quite well in Kenya as well as corn. But they won't change to wheat because they don't eat the wheat they eat the corn.

Atherton: We have to be mindful of the political economic content in which such a model might be moved to the developing world I think that part of the reason that farmers in fact a good deal of farmers grow the crops that they grow has to do with a larger political economy. I would also say that you are going to have to add a level at the bottom it is not entirely clear that we can assume that increased production leads to improved household nutrition and benefits each member of the household equally.

Gabel: One response to the contextual thing is to look at what we are thinking about obviously I would love to be able to test this is to not look at the solution or what it is that you are proposing to do interms of the country, but look at it in that power structure, but to look at it in terms of a zone that is smaller than a country. Mario would like to impose upon you to describe what you are gong to be doing in Costa Rica.

Kamenetzsky: In Costa Rica there is an organization of the American States and World Bank training programs young men from small community in the west coast of Costa Rica is the first one of the community to botain a university degree in administration of rural enterprises will go back to the community and try to develop around this community a regenerative zone in Costa Rica. For these purposes with the support of USAAD he will come spend some time , he will learn how to organize a college that combines education with production. He will visit the Woodrow Wilson in North Carolina, he will go and visit comparative of the small fisherman in Maine, and then go back to the community and place to use these tools to create around this community a regenerative zone.

Blobaum: It seems to me that there is a lot to be said for theory. But that we are really swimming upstream unless policy is changed. In our own country for example, and I think we have to have some credibility if we are going to suggest this to others. We are moving very rapidly toward a global approach to American agriculture. More imports, more exports, less local production and there is virtually no encouragement at the government level, certainly in the federal government examples to some extent in the states here and there. What we ought to do is take the ideas that Medard is talking about and apply them here as well as there. I think that if the government is not with you in any developing country then this is just not going to go because there is a very strong drive toward a global economy which works against the local economy as I see it.

Gabel: What we are talking about is not anti-global economy, it is not trying to cut the zone off from the rest of the world. But, what we are talking about is to let's increase our self-reliance. Now, that is one part, the other part is I would like to respectfully disagree with you. That is absolutely true if you are standing in Washington, DC. On a local level, in Chester, PA and in parts of Arkansas and elsewhere things are not going in that direction because the system has failed, it has fallen apart.

Kamenetzsky: Perhaps the best challenge you may have is to try these ideas in the developing world is to work with the better organizers and non-governmental organizations who have reached a certain amount of a certain number of people in the community and who can immediately put this methodology, these tools into use.

Jordan: One of the problems I am faced with is the lack of information I have sometimes. I'm afraid that we are trying to reinvent the wheel in a lot of our developing projects. I think there is a need for an organization which could pull together from around the world the development projects that voluntary organizations are doing and that have been successful.

Summary of the other discussion:

Dover: Are you basically setting up consulting series for these towns?

Gabel: Yes, we are basically consultants. But people need a manual to set the process in motion. Then they don't need us.

We have indexes to measure the positive/negative impact of various strategies.

Prindle: The problems in Chester County are different than the problems in Africa. There is a problem of retraining and institutional development. The model Medard is presenting is much more applicable to developed countries than developing countries.

Gabel: We are not talking about regenerative agriculture in Chester. We are talking about linking farmers and buyers in an Ag-Market search. We are using it as a tool for business.

For example, a lumberman in Arkansas directly benefitted from our survey by employing more people. He started a door-making business using his lumber when he previously imported the doors from another manufacturer.

The tools we've developed for Chester aren't directly applicable to Africa, but the principles we have developed could be used.

Wheeler: Who else around the country is doing this sort of community development work other than Rodale? Have you done any work trying to elucidate the relationship between the environmental costs of a farmers management of his farm and the community?

Gabel: We've developed the tools, but really haven't conducted any solid research. We are just getting started.

Carr: The power base in countries put certain value on money, so it is less expensive to import goods than grow/develop in the country. Grass roots can try all they want and may not get anywhere.

Grenoble: In a project in Swaziland the government put a ban on importing fruits and vegetables that could be grown there. But the end result was that the price of fruit and vegetables went up. The large producers were growing all the fruits and vegetables. The small producers couldn't compete.

Gabel: With the doormaker example, there was no law passed, and it worked. You need to work at the level of Joshua and his community rather than within political power structures.

Lijewski: First I would like to hear Joshua's feelings on this discussion. And second, power structure should not be excluded.

Mukusya: We need to target our thinking toward a complete life system at the village level. All levels within the village.

Gabel: The local power structure is specifically included.

Morgan: To reiterate what Joshua said those things that build the village are not always easily available. We need to build those thinks in order to help village.

Barry: Back to Grenoble's project. It failed basically because of poor planning. Project should have coordinated small farmers to compete with large farmers.

Short: The concept of Regeneration has grown on me in the four months I have worked at Rodale.

Regeneration politics is supremely democratization, decentralization, self-reliance. If we are asked how to change social and political systems to encourage participation, change information systems to get information to those who really need it, farming systems to help women, what would be necessary in changes to the aid systems.?

Prindle: USAID has a new policy of giving dollars to PVO's because we are now having to spend more dollars with fewer people to manage projects. USAID also has trouble with universities that are not willing to try intercropping and other new research. How can we find those who would be willing?

There is a need for more sophistication in planning -- but that means higher salaries and change in salary structures.

Leibhardt: 50% of AID's funds are going into research. We need to get more of the existing information to the village level.

If the land grant system doesn't want to do the necessary work, then we need to find someone who will.

Meyers: Changes are being made. Some regenerative techniques were evident at the Agronomy meetings in Chicago last week. Universities are realizing that this work is important and are beginning to respond. I feel there is already some movement in that direction.

Bakker: There is so much red tape necessary to work with USAID. USAID is using PVO's to channel work but the red tape needs to be cut. It took three months to get rice, from USAID instead of 24 hours if it came from close resources. We need work in that area.

Kramer: As more USAID goes through PVO's they will demand more professionalism. One focus would be to use USAID partnership funds for strengthening PVO's technical staff.

Morgan: These are common problems but we need to work together for solutions. Think over lunch how to make this happen.

INFORMATION NEEDS AND CAPACITIES FOR COLLECTING, PROCESSING, PACKAGING AND DISSEMINATING IDEAS ON REGENERATIVE AGRICULTURE

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"A change in development approach will require a great deal of discovery, trial and error, and new learning on the part of program designers -- not to mention a good deal of 'unlearning'." -- Philip Coombs, leading expert on education in developing countries (Woods, 1983)

"Our conviction is that, despite the errors of the past, it is still possible for Africa to become self-sufficient in food production. But there is a prerequisite: Africa must conceive of an authentic development strategy which takes into account our experiences, our failures and our successes." -- President Seyni Kountsche, Niger President (Timberlake, 1985)

INTRODUCTION

What is the information that needs to be collected, processed, packaged and disseminated? Before answering that question too quickly, refer back to the above two quotes. What we propose in this paper will require a great deal of discovery, trial and error, and new learning -- and perhaps a good measure of unlearning. But more importantly, it will require a well defined focus on information which is particularly unique to the experiences, failures and successes of farmers and researchers in Africa and in all developing countries. In short, a focus on internal regenerative agriculture ideas, data, technologies, techniques and systems -- and the practitioners or users of those techniques. No longer can or should we only look externally to the modern, scientific breakthroughs of the Western World. As the president of Malawi has been telling his people for the past twenty years, Malawians should not look to others for wealth, but should look "under their own feet." (Partnership for Productivity Newsletter, Fall 1985)

"Peasants have much to learn from agriculture researchers, but so do researchers have much to learn from peasant farmers," writes Lloyd Timberlake in Africa In Crisis. "Lines of communication have never been effectively opened in either direction; until they are, neither will benefit, with African agriculture and the environment on which it depends being the main losers. The scientist has attempted to impose inappropriate solutions from outside, with little knowledge of the small farmers' priorities or realities. The farmer has ignored such advice, and more often than not has been right to do so." (Timberlake, 1985)

We need to step back from the present paradigm and envision the possibility that African peasant farmers have a body of knowledge which has sustained them throughout their history and can sustain them in the future. Why always look externally for agricultural wisdom? It is our contention that that agricultural wisdom has been there for thousands of years. What is needed is a process of unearthing that information, finding the success stories, packaging those success stories and traditional wisdom, and sharing them with other farmers and even with agriculture researchers.

Yes, we need to open the lines of communication. And when we do we will find wonderful things happening. It will indeed take a great deal of trial and error, new learning and a good deal of unlearning. The situation in many developing countries is extremely grim and "successful" is an adjective we can't attach to many development programs to date. Why not try a new paradigm? As Dick Wheeler, former president of Winrock International, told us recently, "Developing country farmers are ingenious -- people who in the long run will resist being tampered with." (Wheeler, 1985)

Why not tap into that ingenuity? We at Rodale Press did just that. And in the process we developed an information collection, packaging, and delivery system which has moved thousands of U.S. farmers to a practical implementation of regenerative agriculture. We believe the same process of finding the agricultural success stories and sharing those successful techniques with others through the publishing process can be accomplished in Africa. More on that later. First some background.

The ingenuity we tapped into for our thinking about and development of regenerative agriculture came to us from the Third World. What we are doing now is just bringing back to the Third World an idea for food production improvement that comes from deep within the experience and history of the Third World itself. We, following the footsteps of Franklin Hyde King and Sir Albert Howard, have taken the essence of the methods that allowed Third World people to live with considerable success for thousands of years and are trying to make these methods even better. So we are, in truth, keeping alive a spark ignited in the Third World, and have an opportunity to send it back in bigger and brighter form.

Here are some examples of what we learned, taken from Franklin Hyde King who describes centuries-old practices of Far East farmers in his book, Farmers of Forty Centuries. Note how "modern" and regenerative these practices are.

> "It was not until 1888, and then after a prolonged war of more than 30 years, generaled by the best scientists of all Europe, that it was finally conceded as demonstrated that leguminous plants acting as hosts for lower organisms living on their roots are largely responsible for the maintenance of soil nitrogen, drawing it directly from the air to which it is returned to the processes of decay. But centuries of practice had taught the Far East farmers that the culture and use of these crops are essential for enduring fertility, and so in each of the three countries the growing of legumes in rotations with other crops very extensively for the express purpose of fertilizing the soil is one of their old, fixed practices."

> "By planting in hills and rows with intertillage, it is very common to see three crops growing upon the same field at one

time, but in different stages of maturity; one nearly ready to harvest, one just coming up, and the other at the stage where it is drawing most heavily upon the soil." (King, 1911)

How similar does that sound to the ridge till methods currently being heralded as one of the new low input agricultural methods for reducing weeds and maintaining production yields?

Internal Information Resources In Africa

We are sure it is possible to find similar regenerative techniques being practiced today in Africa -- but with little attention being given to them. Perhaps being purposefully overlooked. According to Goran Hyden of the Ford Foundation, speaking at a special workshop on Africa organized by the Lutheran World Federation at the Ford Foundation headquarters in New York in October of '85, "The institutional vacuum that now exists on the continent and which prevents any effective move toward overcoming the crisis is the result of a blind pursuit of strategies aimed at making Africans more effective Westerners rather than encouraging them to find their own solutions to the continent's development problems." (Hyden, 1985)

Hyden goes on to say, "in the past, considerable efforts were devoted to 'teaching' the African peasants methods which the Europeans considered superior. For instance, monocropping was often insisted upon often at the expense of indigenous intercropping practices. Whether these methods, in fact, lead to improved husbandry has been disputed in recent years... Africa's development record to date shows very clearly that the local knowledge and experience is often superior to that of 'experts' and policy makers. In most instances, however, this has become evident only after expensive investments in time and money have been made by public institutions." (Hyden, 1985)

Paul Rippey, a program director for Partnership for Productivity, commented recently following an African Strategy Conference, "This conference has made it even clearer to me that there is not so much a lack of solutions to Africa's problems as a lack of knowledge of the solutions that already exist. Of course, there is still a need for breakthroughs and plant breeding, new cropping techniques, and so on, but Africa is not hungry for want of new solutions. It is hungry because of the widespread failure to manage resources in accordance with what is already known about the best way to manage them. One of the best ways to disseminate information is the press. Rodale has a holistic approach to publishing; you mix the practical with the theoretical, and you speak to a variety of audiences. This is so much what is needed in Africa today." (Rippey, 1985).

Numerous other examples could be cited showing that there already exist plenty of African success stories that need to be packaged and shared with other farmers, researchers and policy makers. But what about new research? Is that research to come from outside Africa, too? Not at all. At least not all of it. There is much to be said for internalization of new research also.

Not only has international research ignored African food crops; much agriculture research in Africa concentrates on non-indigenous crops. It tries to get crops from elsewhere (wheat, Asian rice, potatoes) to adapt to African conditions, rather than raising yields of crops already well adapted to the continent. But there are three other ways in which African crop research often fails.

1. It attempts to create varieties, of either local or exotic crops, with characteristics adapted to a type of intensive farming often unsuited to local conditions.
2. It concentrates on the technical aspects of agronomy (yields, rates of growth, stem length, etc.) at the expense of social and economic research to discover the acceptability of any innovation.
3. It fails to learn from local farming practices." (Timberlake, 1985)

Here are other examples. Much work has been done on trying to grow improved Asian rice varieties along the Niger River. This rice has short stems, so the growth goes into grain and not into the stalk. That is if the water levels are carefully controlled. However, African rice copes with flooding by growing faster than the rivers rise. So it has greater survival potential than Asian rice and it doesn't require labor to control water levels. It also is more glutinous than Asian rice and thus is preferred by women in making the traditional porridges. Yet researchers prefer Asian rice.

According to Lloyd Timberlake in the book Africa In Crisis, perhaps the best reason for radically altering present African agriculture research and development practices is that the input from the lab approach has been tried for many years now and has not worked well. Paul Richards believes that 'people science' is worth pursuing, not out of admiration for the peasantry, 'but on the grounds that it is good science'. (Timberlake, 1985)

Yet this is the very type of research that is given short shrift in the traditional information transfer systems. There is no doubt that African nations cannot go it alone, so to speak, in terms of thriving on centuries-old knowledge and new internal research. "Not even the most advanced technological societies could exist without outside resources and ideas, and African countries cannot make it alone. But similarly the West needs to be sure not to try to 'fix' what is already working. For example, the solution to low agricultural productivity is often not to replace indigenous crops with imported crops, but to find the gaps in systems of traditional agriculture and fill them." (Partnership for Productivity Newsletter, Fall 1985)

A New Extension Paradigm Needed

But given this concept of local direction and reliance on internal knowledge and research, is this a good foundation on which to base technical improvements? In other words, how can peasant agriculture improve if the improvements are based solely on peasant knowledge? According to Lloyd Timberlake, "In fact, projects based on and building from local knowledge are the only way technical change can come about. Local farmers know enough to know what is better, to seize on it and to use it. But for this to happen more often, there will have to be a complete turn around in agriculture extension. The extension workers see themselves as selling outside solutions to peasants. But they will have to come to see themselves as taking the peasants' problems to the researchers. (Timberlake, 1985)

And we would add there is a need for extension to take the farmers' problems to other farmers. But we don't think extension services will make it happen. There is just too much evidence to suggest that they're ineffective and not cost-effective. "A widely held perception among professional agriculturalists during the past decade has been that necessary technology has been available and that the deficiency has been its dissemination and adoption -- a justification for new investment in extension -- but research reviewed by Hornick does not suggest that farmers are ill informed to facts enabling them to reap greater benefit from their farm resources," (Op. cit.) Bernard Woods writes in his paper, Altering the Present Paradigm: A Different Path to Sustainable Development in the Rural Sector. (Woods, 1983)

Woods gives ample evidence throughout his paper questioning accepted lore that extension services are vital for transmitting new knowledge and skills to farmers.

According to an International Labor Office report, "Extension advice has two somewhat contradictory failings: it is often wrong, and it is often unavailable. African governments spend little on it. In 1982 when the government of what was then Upper Volta was spending the equivalent of $8,000 per year on every soldier as opposed to $7 on every citizen, extension workers could not get petrol to drive out of the capital. In 1980, the travel budget of the Zambian Ministry of Agriculture could buy only 1/5 of the petrol it could buy in 1973, leaving agriculture staff esentially desk-bound." (Timberlake, 1985)

Many of the same conclusions are reached in a USAID paper, Lessons Learned from AID Program Experience in FY1984. "The 1984 reports reveal that many agricultural development projects aimed at effecting the adoption and use of small farmers of more productive modern cultivation practices are falling short of their goals. The increases in local, regional and national productivity and income envisioned in these projects are not being realized, despite the fact that the required technologies are available. In most countries the reason for this is that the delivery system for technologies' inputs are inadequate in reaching the great majority of rural farm families. In some countries there is another reason: the cultivator deliberately and after due consideration declines to adopt a new technology, even though the required physical inputs, and an extension service to deliver them, are available." (Development Associates, 1985)

Why? The report cites the fact that the U.S. Extension Service has been used as a model for the developing countries -- with its high cost and tradition of not personally involving farmers. And we would add that extension gives too little credence to the existence and value of the farmer's own knowledge. The USAID report further states that once cooperating farmers are "personally involved, they readily convert to the new varieties and methods and become active, positive participants in the search for still greater yields "using their own knowledge as inputs additional to those of the scientists." (Development Associates, 1985)

Howard D. Ray, Ph.D., Vice President and Director of Agriculture Sciences and Technology, Academy for Educational Development, in a three-part series entitled, Incorporating Communications Strategies Into Agriculture Development Programs," points out, "traditionally, the job of agricultural communication has been to motivate the farmer to 'want' to use a new idea and then to teach them the skills and knowledge to apply it. Too often the focus has been on the innovation rather than on the farmer. Its benefits have been described in the perspective of the project, ignoring the farmer's desire, constraints, cost, risk, etc." (Ray, 1985)

Yes, extension and other communication devices have been a one way street -- top down from researcher to farmer. There certainly has to be an exchange of information between farmer and researcher. But even more importantly, the information that is exchanged can't always be that of the experts. In short, it can't always be external.

Why? Because the farmers themselves are making things happen. And their findings need to be shared with others.

Based on preliminary research from IITA in Ibadan, Nigeria, and the results of the local research in Togo, farmers in the PADCOR program are testing short cycle local varieties of sorghum. One variety, Naga Red, originated just across the border in northern Ghana. In order to get two crops from one field in a single growing season, there is an on-going test of planting cow pea ahead of short cycle sorghum. The cow peas are planted in May, harvested in July, with the remaining green matter turned under and the short cycle sorghum planted to use the nitrogen produced in the soil by the leguminous cow pea. Since it is soil fertility which is the limiting factor effecting increased production in this area of Africa, farmers are testing the regenerative practices which will have a direct impact. They are also intercropping with pigeon pea and leucaena, turning under crop residue rather than burning it, increasing the plant density of ground nuts and testing the growing of soy beans. There are 25 farmers who are conducting these on-farm trials and now they have begun to teach other farmers the regenerative practices which they have learned. (World Neighbors, 1985)

Investigations of farming systems in West Africa have turned up a remarkable array of other sophisticated techniques and "home grown" technologies. Farmers use their own R & D of trial plantings and input-yield data. A 1942 study of rice varieties used by Mede planters in three districts of Sierra Leone found 20 distinct varieties, some fast growing, some slow, and various types meant for different land and water conditions. Knowledge of these varieties and the research on them turned up solutions better than anything Western science had to offer. "Despite the publicity surrounding the green revolution's miracle rices, two of the most successful improved upland rices in Sierra Leone and Liberia, ROK 3 and LAC 23 are of local provenance," writes Paul Richards. (Timberlake, 1985)

Richards further describes recent FAO fertilizer trials in Plateau state, Nigeria, which compared local farmers' cultivation practices with those suggested from outside scientists. For monocrops of sorghum and maize, the outside cultivation techniques proved best. But the best yields all around resulted from using fertilizer on intercrop stands -- the farmers' usual practice. Where both plots used fertilizer, intercroppings of yams and maize achieved a value/cost ratio of 77.3 using farmers' cultivation practices, but a ratio of only 24.6 using the external cultivation practices.

Another good example of the use of indigenous resources and technology married with outside information requested by local government and farmers themselves, is the Resource Efficient Farming Methods (REFM) project in Tanzania being developed in cooperation with the Rodale Institute. This program is currently in its second Phase, Phase III will begin in 1986 and run through 1988. In addition to the pilot projects in the targeted districts, additional research is being carried out by TARO Research Institute, Sokoine University of Agriculture and Uyole Agriculture Center. Based upon the results of this range of experiments, the successful technologies will be extended to farmers throughout the country. To quote Tanzanian agronomist, Dr. G. A. Vahaye, coordinator of the REFM Project, "great progress has already been made... The project has been emphasizing maximum use of the resources and technology already available to improve agriculture production while minimizing costs." (Vahaye, 1985)

Success with regenerative agriculture practices is not limited to the needs of Africa, but provides an appropriate response in other resource limited LDC's. In Honduras, Fredy Zelaya left his land in Guniope and went to Tegucigalpa, the capital, to try to find work. He found himself, like thousands of others, with limited employment and sinking further and further into alcoholism and despair. Then he heard from his brother that he had just learned how to get more from his land without having to purchase external inputs like fertilizers and pesticides. Fredy was encouraged to return to his village. He did and after seeing what was happening on the land of other small farmers and then participating in several simple training courses, Fredy began to make changes in his land. At first it was contoured to conserve the soil and the water. Slowly he began to build his soil by adding compost and using leguminous green manures to boost the available nitrogen in his fields. Today, three years later, having regenerated his land, Fredy is producing almost $400 worth of vegetables per week during the peak season.

In Honduras, over 5,000 farmers are either beginning to, or are already practicing regenerative agriculture. For the average farmer, output has now increased 150-200% over previous levels. For the small farmer -- the one working between two to five acres, who has been left out of the external resource intensive "green revolution," this re-discovered way of farming has the potential of having a dramatic impact on the world's food production. (Daily Oklahoman, 1984)

There are literally thousands upon thousands of examples such as this, examples of agricultural techniques that have worked for millennia and are still working today. There are also numerous cases of indigenous techniques made even better with the help of new technologies and information. There are many such success stories.

The Publishing Process -- Finding & Sharing Internal Information

Even the best information is of limited value if not widely disseminated. As shown in this paper, success stories among farmers, researchers, policy makers and governments are there. When included in the information dissemination and research process, farmers will accept methods used by their fellow farmers and will even consider new methods. "Farmers and herders with little access to economic and natural resources hold the key for increasing food production in Africa. The technologies that help these low resource producers are largely lacking, especially in developed countries such as the U.S. Some of these technologies can be adapted from current traditional practices. The need also exists for new types of technologies, especially given the large projected increases in total and urban populations." (OTA, 1984)

The challenge, then, is to find those traditional practices that are working, find out why they are working, determine if there is any need for modern science and technology to improve those techniques, then share that information with others to help them to thrive. What we just described is in great part the Rodale Press publishing process, which has been so successful in finding the regenerative gardening and farming success stories among U.S. farmers and gardeners and sharing their techniques, their ideas, their concepts with others who can use them. Over the past 50 years we think we have done an excellent job in digging out that information and turning it into magazine copy, newsletters, books, pamphlets, conferences, visual aids, etc., that are helping Rodale's audience become self-reliant in gardening and agriculture. We know how to package and disseminate this information.

No, we don't think we can transfer this process in its entirety to the Third World and expect it to work in the same way it works here. But we certainly think that the publishing process, adapted for specific Third World areas, can breathe fresh air into current methods of technology transfer. Perhaps one of the most important things that is needed for improving food production in Africa is not the export of Western knowledge, but the export of the process of gathering and disseminating relevant information. That process, together with the regenerative concept and its research are perhaps the greatest assets the Rodale Institute can bring to Africa and to other developing countries.

The publishing process speaks to the concept of mass communication. According to Bernard Woods of the Operations Policy Staff of the World Bank, "forms of mass media hold great potential for rural development; they have a cost advantage and have been shown to be able to perform functions in which other communications modes have failed, but their potential has not been realized...Forms of distance education and communication technology provide means of adult education and information transfer with application in all traditional sectors involved in rural development; these media are able to supplement traditional approaches and reach segments of rural communities little touched by earlier approaches." (OTA, 1985)

Jose Luna Castro in a 1977 seminar on development communications defines development journalism as being "largely rural based, popular rather than elitist, practical rather than theoretical and esoteric; and service-oriented...it is involved in the community's growth rather than detached from or above it." (Castro, 1977)

What Castro is saying fits very nicely into what we would project as a publishing model for the Third World. It has to be rural-based, popular, practical, how-to oriented and part of the community itself.

We would envision the placement of a small staff of Rodale-trained people with publishing expertise, based in select cities in Africa. A good example might be Harare in Zimbabwe. We might even want to consider the concept of a Peace Corps in publishing.

In any event, this staff, with its good writing skills and a solid agricultural background, would relate to all PVO's, NGO's and government agencies on an equal basis and would represent the regenerative point of view. With the cooperation of the PVO's, NGO's and government agencies, these country contacts would survey the current regenerative agriculture practices in that country, and would see not only what is being done in the field, but also what has been reported in the literature. Considerable research has been conducted in Africa, not only on experimental farms but also by large land holders and village farmers alike. The British colonial administration maintained an agriculture and livestock research and extension service in its overseas territories. The height of the research activity took place between 1930-1960, when agricultural chemicals were not widely available in Africa, and the field of applied ecology was being recognized. As a result, many of the research and development projects involved elements of regenerative farming, such as the use of rock phosphates, green manures, compost, livestock manures, and agroforestry.

The results of this work were published in the form of government documents which were not widely circulated: annual reports, research and extension bulletins and special reports (National Agricultural Library, 1984). The challenge is to collect and collate that research information. It would require 1 to 1 1/2 years for a qualified researcher to search and compile the information from sources in the U.S., Canada, Great Britian and East and West Africa.

How can this information be shared at the local level? We will not go into detail about the process by which Rodale collects and shares information with U.S. farmers through The New Farm magazine. Suffice it to say that inherent in the editorial process are the mechanics of knowing how to get the information, filtering it through the editorial lens, selecting the audience, and finding the ways to disseminate it locally. In terms of audience, since it is the small farmer who will ultimately be responsible for the boosting of production (as pointed out earlier in this paper), it is to him, or more often her, that the message must be directed. Not only is the small farmer the most important to reach, but he or she is often the most difficult to reach. There exist the problems of language, culture, literacy, distance and media.

In addition to the primary user, there is also a list of potential secondary users such as trainers and extensionists, village leaders, program leaders, PVO's and NGO's, church groups, policy makers, government agencies, agribusiness, and finally those who have the capacity to influence U.S. policy makers -- the American public, and for Rodale specifically, the readers of its publications. More on the international audience later.

We'd like now to return to the challenge of reaching the small farmer. One way to accomplish this task would be for the local publishing staff to survey both PVO's and NGO's in the countries in which they are based to locate all local agriculture mass media vehicles used there. The next step would be begin feeding regenerative information through those channels of communication. For example, Malawi's Ministry of Agricultural Extension AID's Branch (EAB) as of early 1985 was organized into eight sections: management, publications, radio, evaluation and action research, mobile units, films, editorial, and photography. The EAB unit even prepares and publishes a bi-monthly farmers' magazine, Za Achikumbi. The farmers' magazine would be a perfect vehicle for sharing the success stories of regenerative agriculture in Malawi.

Another example is the Lesotho Distance Teaching Center. Although its programs are not strictly directed at farmers and agriculture, it does provide practical skills to rural people through both print and radio programs. The Lesotho Distance Teaching Center would be an excellent partner in helping to collect, package, and disseminate information about regenerative agriculture.

How can the appropriateness and validity of incoming information be best determined? Using a close linking process between Rodale's scientists, professional associates and the local contact staff, a system of checks and balances can be established. First, a set of criteria will be established to serve as a reference point in analyzing incoming information. When questions of validity arise, the information will be forwarded to Rodale scientists for review and validation. Secondly, those scientists would regularly visit the overseas program areas and work with the local staff, training them to look at projects with a research orientation, and helping project implementors to add a research mode. The emphasis would be on "quick and clean" research more than on a "pure science" approach.

While this model certainly needs to be tested, We are convinced that it is doable and will produce results in terms of gathering the local success stories in regenerative agriculture and getting them to farmers who need them.

An International "Sieve"

In addition, this local information needs to be shared internationally. One model on which to base an international information sharing network is the current "Sieve" operation at Rodale Press. The Sieve screens more than 1500 journals, and abstracts articles of relevance in nutrition, health and gardening. These abstracts are distributed to the

Rodale editorial and research staff three times per week and keeps editors and researchers on the cutting edge of published information. Visitors to the Press are impressed with this unique resource which brings the library to the desk of Rodale editors.

Using this model, we believe it is possible to establish a two-way interactive network which solicits, collects, screens as well as distributes published and unpublished information sources which relate to regenerative agriculture in both the developed and developing world. This Sieve operation could logically begin in the Rodale library as part of the current Sieve activity. The elements needed would be:

1. New keyboards and a person uniquely alerted to the types of information needed.

2. A person with experience in agriculture and especially in a developing country which would help the Sieve operation to focus on appropriate information through intuition as well as training.

3. Additional resource materials from published sources, new journals by subscription or by loan, and a wid range of newsletters and reports from development groups.

4. Access to and contacts with a VITA, LIFE, ICE, ITI, IADS, Agro-development notes, Rurcon, INADES, and a wide range of other groups which generate or collect timely information.

5. Steady flow of current public domain documents such as USAID Country CDSS'S, consultant reports, and reports from USAID and other groups working in Third World projects.

6. Information from contact people overseas.

7. Other information resources which would be uncovered by a team of creative people involved in the collection and Sieve operation.

Processing the information would be carried out much as the current Sieve operation is functioning. Criteria would be established for including information in the Sieve -- level of investment, regenerative nature of idea or practice, inputs external or internal to farm or region, effect on health and safety of farm family, effect on environment, sustainability over time, and many others. This list of criteria would evolve with the Sieve itself, and would be responsive to the needs and understanding of the clients at various levels.

Disseminating The Information

Among the challenges in this information network are the forms of publication and distribution methed of the Sieve itself and its spin-off products. Here are some possibilities:

1. On line service by computer link to provide both abstracts of articles and full text of requested information sources. This

will require a degree of sophistication, but is not beyond current technology nor what some groups are implementing right now in the field.

2. Hard copy abstracts and availability of full text of the sources.

3. Summary newsletter of most critical resource pieces, based on what is most requested by the above two routes and what appears to the Sieve operator to be most immediate and relevant.

4. An extension journal outlet, with drawings, posters, abstracts in three languages, film strips, and other non-verbal or non-traditional educational devices.

With Rodale's long history of successful publishing and the expertise that goes with that, we are suggesting here that in addition to the Sieve operation, consideration be given to the development of an "information sharing" type of newsletter for Africa. It could disseminate broadly agricultural technologies from "on-farm" research, successful development activities, as well as from local and international research stations. This newsletter might evolve into an international regnerative magazine at some time in the distant future, perhaps 3 to 5 years. There is a tremendous need for such a vehicle to disseminate findings to practitioners and to other researchers to avoid duplication of research among countries. Collaboration should be considered with other international organizations such as Winrock or IITA in Nigeria. Such collaboration would also bring with it expertise and manpower useful to launching the publication more expeditiously.

Publication of agriculture research data and recommendations has traditionally been through formal, reviewed journals which circulate among the scientists in the international research community. The submission of the manuscript and the review process is a rigid and time consuming activity which causes extended delays in appearance of materials and often discourages research people from publishing valuable information.

The majority of research in the developing world is not published or is only summarized in reports and obscure bulletins. An alternative outlet which provides for efficient publication and distribution of this information is badly needed.

An even more relevant body of information is the collective experience of farmers and extension workers in a developing world. The vast majority of this knowledge and experience never moves beyond a few neighbors and relatives who happen to observe specific practices or hear about new approaches to farming. The purpose of the journal would be to capture this fugitive information through, for example, the Sieve operation and make it available to farmers and extension people, PVO's in the U.S. and other countries, international development organizations, Peace Corps volunteers, African and international research institutes and training centers, African development organizations, and Africans who are interested in rural development. (Many educated Africans maintain ties with their villages and contribute to its development.)

This paper is not the place to expand and develop this publication idea in detail. Our intention here is to plant seeds and a dream of something which can and should be done. There is information out there among the peasant farmers, diamonds in the rough, so to speak, that needs to be uncovered and polished, so that and the beauty and meaningfulness can be shared with others. The publishing process is uniquely designed to do just that. Yes, it will take some trial and error and an openness to new strategies.

In the Office of Technology Assessment memorandum, "Africa Tomorrow," tremendous emphasis is placed on the need for information exchange. One of the recommendations in this memorandum is the activation of a satellite and computer link up system for the sharing of information. If such a link-up could be established, the regional processors could forward information to the central processor (the Sieve, for example) and the central processor could, after further sifting incoming information, forward the relevant information from one region to the next, and to any subscribers to the service or publication.

We think it is going to work for all of us. We face many challenges on the path ahead, but regeneration is a cooperative venture which offers us a workable vision that can lead to a properous future.

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Additional points made in the presentation:

None made.

Key discussions in depth:

Tull: I've tried here in a couple of pages to just quickly outline some points these are not meant to be the ten commandments of how to do this but just some points that might stimulate some further discussion as we go into the discussion period. It has been my experience working in both Africa and Asia that what is being outlined here is possible. There are two approaches that can be used the first approach is getting regenerative agriculture information collected packaged and desseminated through the use of existing publications. The second way is a cooperative venture with local institutions or agencies to create, publish or produce educational or information materials. Procedurely what would have to happen is obviously you would have to survey and find out what is there. I think the first step is to go via PVOs, NGOs, AID and individuals to find out what are the potential publication that information might be plugged into. The second thing is the establishment of its system for the information collection and the dessemination of that information out to those existing publications.

The other side of this is the question of cooperating with local agencies and publishers to create new material. To say materials I think it is a wide open field I think it depends entirely on the local condition, I think that when we look at local regenerative information we can look at it via newsletters, via slide sets, via audio casettes, radio you name the kind of material and the potential is there and certainly the potential is rapidly developing with the advent of the 8mm video for the use of video. I think another important element is what is the local funding capacity? How much local resources are there? We are talking about internal and we certainly better look at that? We got to establish an information collection and preview process or a sieve process, John will go into the sieve process a little bit later here. Obviously determining the type of materials that are needed. Determine the dessemination procedure. Develop a feedback loop or procedure system. Establish the format for materials or the type of materials that are going to be needed based upon that local need. Produce the materials and begin dessemination.

Basically, that is the way I'd see these are possible approaches that would be sued to deal with this, there are certainly other approaches that could be used to.

Haberern: How do we get information locally and this is an answer to Wimm how do we get it circulating internationally? Another thing that we do well at Rodale Press is just something that we started 20 years ago which is called the Sieve. There was no information being exchanged among editors say between Prevention and Organic Gardening or our other magazines or between the Book Division and our magazines. I said let's form a central core of people that will get all the journals it is now up to about 1500 and these people will abstract the journals keeping in mind that these people these Sieve experts know what the editors and researchers are looking for. They go through these journals whenever they come in and three times a week they are issued a thing called the Sieve. It looks something like that. The editors and researchers go down the list and they read things. They circle those items put their names behind it and the next day appears on their desk a complete article. We have expanded the Sieve and we have something called the Vitamin A Sieve. The Vitamin A Sieve is about 2 months old and it is an approach to the problem of Vitamin A deficiency in the Third World. As Ken said we might even do a Sieve like this from the Rodale Press library. Of course, we would need new key words, additional resource material, access to contacts with VITA, LIFE, ICE, IADS, etc. but with our special expertise and the fact that we are already doing this and doing it extremely well I think we can roll up our sleeves and get to work. I think that it is possible to develop a networking procedure to come up with an international Sieve which might look something like this. Ken talked about the regional Sieves and these local information producers. This information luncheon is shared locally, should be shared internationally by focusing it in, and sending it in to the central Sieve. Potential users would be the local farmers, extensionists, planners, and researchers. We also need information that comes from other information providers like this workshop, like the PVO newsletters, like the information from LIFE or INADES. This all feeds into this central operation.

Kramer: My feeling in l..king over your proposal, I am very excited about it. My feeling is that you are going to have to be a lot more pro-active in going out and digging out that material.

Tull: I agree John, it is not going to be easy and that is why I said t is hard work, roll up your sleeves, type thing. I think the most important thing is to cooperate in partnership with the people who are already reaching down to the grassroots. We in our discussions as to what the potential is only saw this happening by putting regional sieve operations in place. Initially somebody has to go out and not just survey the PVO's and the NGO's in a particular region, because they then need to follow up on that, they need to be able to go out and look at the local research that is going on, and the need to develop at that regional level, the capacity to go out and bring that information in. I know from my own past experience that you have to do that first and it is only after you've gone out and started bringing the information in and getting the information back out you start creating that loop that's needed, then people begin to see it is worth their while to try and get information in it.

Prindle: The way you'd be most helpful to the Africa Bureau is by adopting a country's specific approach and a crop specific approach so that for instance, what sorts of intercropping and rotations and soforth make sense for maize, make sense for sorghum, make sense for a couple of other key crops that the agency is working on and use the country net. I think that to take a broader than specific target country and specific crop approach is very, very ambitious and may lead to nothing.

Scarborough: My concern is from an implementation parameter and that is that we find that the agriculture research, even that which is good and applicable and appropriate, you run into a dissemination problem.

You have to ask yourself how do you extend the mobility of the extension wing, be it formal or informal, in terms of the PVO's and obviously one way this can be done by the utilization of written messages, particularly in local languages and the vernacular that are tested relatively low risk and are simple and straight forward. To say that this approach is not relevant at this point in time may be premature. I think it should be given an opportunity to prove its mettle and it can only be done out in the third world context, and I for one as a project manager and ag-development officer, would be anxious to see if something like this could be used that would create a least cost more efficient, more effective extension outreach delivery component or complement.

Sands: I'd like to touch on this topic of how wide or general a pool do we draw from. Perhaps in relation to that I have a question that may help us direct it and that 's really what are we seeing as an audience, who are the clientele for this type of ·ieve. On your chart you have three groups, researchers, extensionists, and farmers. As a researcher, something very broad that pulled from a whole variety of crops and areas would have been very helpful. But in that system they are relying on me to integrate a great deal of information if it's local extension AID or even tougher, farmers, perhaps then the focus may have to be somewhat restricted.

Gabel: I'd like to respond to Debbie Prindle's suggestion that this kind of service it were to get off the ground be limited to a specific country and to a specific crop. I would encourage a broad spectrum rather than one crop, one country. I would think that a bigger sieve or bigger focus would aid the people there a lot more.

I would think that if you consider the developing world you could look at ecological zones. Maybe what's going on in the Sudan or Upper Volta are much more important to cross that zone and there may be more differences within Sudan than there is across that whole stretch across north Africa. Maybe what's going on in Australia is more important than what's going on for the Africans and what's going on in southeast Asia. But it seems to me that if it was organized according to those kinds of ecological zones, there could be very much information transferred. I think the other thing is that researchers and extension people would have a need for information of a different level than would the farmer. The researchers and extension people ought to be integraters of that information and they should be able to blend it up, grind it up, in another form that would be useful, so I think it depends who the final user's going to be. Maybe you're going to have more than one or two types of sieves.

Short: Discussion of many audiences does imply various methods, probably the sieve is suited to a research audience or a policy making audience. Speaking, however, of the most important audience, the poor farmer and the temptation here throughout will be to exclude that person once again or those people from it. Perhaps something we should not underestimate is what Ken was talking about the collaboration with indigenous village groups which exists in many countries, very numerous. There are indigenous PVO's, there are many structures that we have to turn to so the emphasis on internal applies as much to the organizational capacity as it does to the farming capacity.

Soos: I think in Africa we have a more complicated situation than we do in the US because the farmers are not literate and they're not writing their own stories. You have to look at the intermediaries you'll use to work with them and currently what we use is PVO's, NGO's, community organization groups, whatever. I don't think we should underestimate the power of the English language to reach those people, because those people in turn communicate through their normal processes already. I think as a first cut we really do need to reach the PVO's, the development organizations, the local NGO's, all the church community groups, and it's hard to find any villages in Africa that don't have any literate people in them. even if there are none there, they have relatives in the city who come home regularly, some people in Kenya go home every weekend, and will take this information from the city to the rural areas.

Tull: I think we grossly underestimate the indigenous information system the way it works. When a publication comes into a village, whether it's Joshua's house, or people who I worked with in Nepal, when they get hold of a publication, it does not stop at their household. People share information that is based upon real experience and I think if you're looking at materials that are going toward the extensionists, towards the farmer level, there's a couple of things that we can plug in that work. We have found that it's a language about fifth standard. That's kind of a starting point. Anything that's going to be written that's going out to the extensionists and a certain level of farmer it can go out if it follows those rules.

Summary of the other discussion:

Wheeler: Are you suggesting, the establishment of little Rodale Press's (not necessarily owned by Rodale Press) all over?

Haberern: No, not more businesses -- but rather non-profit entreprenuerships. We could even do something like Regeneration Project Newsletter which is just being started now.

Wheeler: What about taking five people from a given country and from Rodale Press and supplying them with information on how to start a small press ... a publishing house?

Bakker: The extension infrastructure leaves a lot to be desired. Lining up a communication source, a publishing service, the idea of using Rodale Press for communicating is applicable and should be given a chance. It needs to be tried in the real world.

Johnson: It would be very useful if we had conclusions that point toward an action program:

1) The collection and distribution of information and

2) The actual research of regenerative agriculture.

It may be useful if people could visit the Rodale Research Center.

Hupping: The Sieve is a starting place that can be built on.

Prindle: Rostering is one way in which Rodale's expertise may be utilized effectively.

To follow up on the idea of pilot countries -- Rodale Press and PVOs need to define roles in getting information out. Regional newsletters can't substitute for this. AID would want to facilitate this process.

Morgan: The suggestion of rostering of resource people is an idea we consider important. Your feedback on this is very helpful.

Ferguson: I have some very interesting projects going on. One is Agro-Tech transfer based on soil taxonomy. Will it/could it work agriculturally? Then it could be turned over to social scientists to see if it would work. The work I am referring to is supported by the Department of Agriculture.

Meyers: I am not clear on the purpose of this conference. Is it more than regenerative agriculture? Is it policy? The interest is there and you have identified resources. The implementation of regenerative agriculture policies would be one purpose. This approach is not that much different from a farming system's approach. Therefore I see it as an add-on, not a whole new concept.

Horne: One follow-up to this conference will be a questionnaire to monitor results.

Liebhardt: Regenerative agriculture is more than the individual component technologies, regenerative agriculture is a whole new philosophy of looking at agricultural problems.

SUMMARY

SUMMARY OF FUTURE ACTIONS TO BE TAKEN BY USAID AND RODALE INSTITUTE

1) USAID Activities:

A) Briefing of the Assistant Administrator/AFR and Deputy Assistant Administrator/AFR.

A meeting will be scheduled to brief AA/AFR and DAA/AFR on the results of the recent Workshop on Regenerative Agriculture. An Information Memorandum will:

1) report on the highlights of the Workshop;

2) inform AA/AFR and DAA/AFR of the consensus of Workshop participants that continued and additional efforts by AID and Rodale Institute to promote regenerative agriculture are indicated;

3) outline recommended "next steps;" and

4) request AA/AFR and DAA/AFR comments on/support for the preceeding.

B) Expanding the AID constituency for regenerative agriculture.

The recent Workshop succeeded in increasing the understanding of and appreciation for regenerative agriculture of a substantial number of AID/W staff. Missions, particularly African, were encouraged to send representatives to the Workshop. Many Mission cited strong support for the initiative in regenerative agriculture but unfortunately also cited constrained travel budgets precluding them from sending participants to the Workshop.

Additional efforts to reach AID field offices should be examined such as:

1) workshops in the field, possibly in conjunction with Mission Director and/or ADO or similar regional conferences;

2) distribution of complete information packets on regenerative agriculture to key field staff;

3) distribution of video-cassette tapes of the December Workshop (after required editing, etc. is completed by Rodale Institute and funding for duplication of the tapes is arranged);

C) Expanding the PVO/Other Organization Constituency for Regenerative Agriculture.

Space limitations for the Workshop allowed for only a small number of PVO and other organization participants. Nonetheless, representatives of these organizations manifested broad support for the principles and relevance of regenerative agriculture to developing countries.

Organizations/institutions who should be reached through means to be determined (including possibly a further conference, distribution of Workshop proceedings, etc.) include:

1) additional PVOs;

2) the Peace Corps;

3) additional staff of universities working under AID-financed farming systems, agricultural research, etc.;

4) other centrally and regionally funded projects.

D) Identifying ways to incorporate regenerative agriculture in on-going agency programs.

Initially this effort will focus on portfolios of S&T/AGR and S&T/RD, e.g. projects such as:

1) Farming Systems Support (936-4099)

2) Development Strategies For Fragile Lands (936-5438)

3) Technology Development Transfer Feedback Systems (936-4148)

4) International Agricultural Research Centers (936-4111)

5) Natural Resources Research and Training (936-5550)

6) Communication for Technology Transfer in Agriculture (936-5826) (S&T/ED)

E) Assist Rodale Institute to develop an international model for information dissemination on regenerative agriculture.

At the Workshop Rodale Institute stated its interest in transferring and using the information gathering and disseminating expertise it has acquired over 25+ years in the U.S. to promote regenerative agriculture in Africa. Workshop participants responded positively to this proposition, and post-workshop discussions among AID/W staff indicate there are many suggestions on how the international mechanism should be structured and operate.

2) Rodale Institute Activities.

A) Rodale Institute will assist USAID where possible in the above activities.

B) Rodale will develop a model for the compiling and exchange of information about international applications of regenerative agricultural principles (Sieve).

C) Rodale will develop a roster of regenerative agriculture expertise to enable USAID and other development agencies to draw on people with expertise in this field in project design, implementation and evaluation.

D) Rodale will develop a series on 8-10 "success stories" in regenerative agriculture to complement "Enough Food."

E) A follow up questionaire will be sent to Workshop participants soliciting additional information on the promotion and development of regenerative agriculture.

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