

## HOW TO INCREASE PUBLIC INVESTMENT ON RESEARCH

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### INTRODUCTION

From society's point of view, the question is whether agricultural research should be considered as a priority for the public sector. In other words, should a major objective be to increase total funds allocated to agriculture research? How to get the support from the public authorities?

The foundation of the analysis is the idea that it is the stress (or crisis), be it of economic or of a social nature, that induces government to take decisions. Clearly not all decisions, but most of them, when heavy investments are needed (DEJANVRY, 1973).

The question is then how to detect signals of stress or when it will arise, to make it known to society and government, and how it relates to lack of investment on research. A related question is how to motivate society to support research.

The paper addresses to these questions. The Brazilian Agriculture is the background for it. But it is tried to have conclusions that are applicable to other situations.

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## TWO TYPES OF PROCESSES TO DEVELOP TECHNOLOGY

For the purpose of the paper two processes are relevant. What separates them is the presence or not of organized research (public or private).

The first process is named Model A. Organized research is not present. What makes the stock of knowledge and technology to grow is the accumulated experience of farmers, their ability to import technology and to adapt it to the conditions of the country. The power of this process to increase productivity (of labor or land) is small. The objective is to maintain the productivity level and to create conditions to expand the cultivated area whenever it is possible. But even in this case the power of the process is limited, if the new environment is very different. For instance, the technology brought by the European and Asian immigrants developed the Northeast and Southern agriculture of Brazil. It failed when it was applied to the Cerrados (Brazilian Savannas - 25% of Brazilian territory, and most of it located in the Central part of the country) and to the Amazon region. Those regions present problems that are peculiar to them, and very difficult to solve, without the help of science.

This unsystematic way to generate knowledge (by trial and error) was responsible for the majority of technologies that were developed up to the beginning of the century. In Brazil and developing countries its influence is still present, and to a large degree, sometimes. But it started to lose importance in the beginning of the sixties.

The second process is Model B. Knowledge and technology is generated by organized research (public and private). Technology is then science based. The transfer of knowledge and technology is through the research system which adapts them to needs of the country. The purpose of the technological development is to increase productivity of land or labor, and to make possible the growth of the cultivated area, when there is land to incorporate.

Depending on the situation one goal prevails over the other.

GRAPHIC I pictures how the processes develop.

The vertical axis measures the amount of technology (models A and B) used by farmers. It varies from 0 to 100 (percent of farmers that use the technology generated by models A or B). The horizontal axis is time.

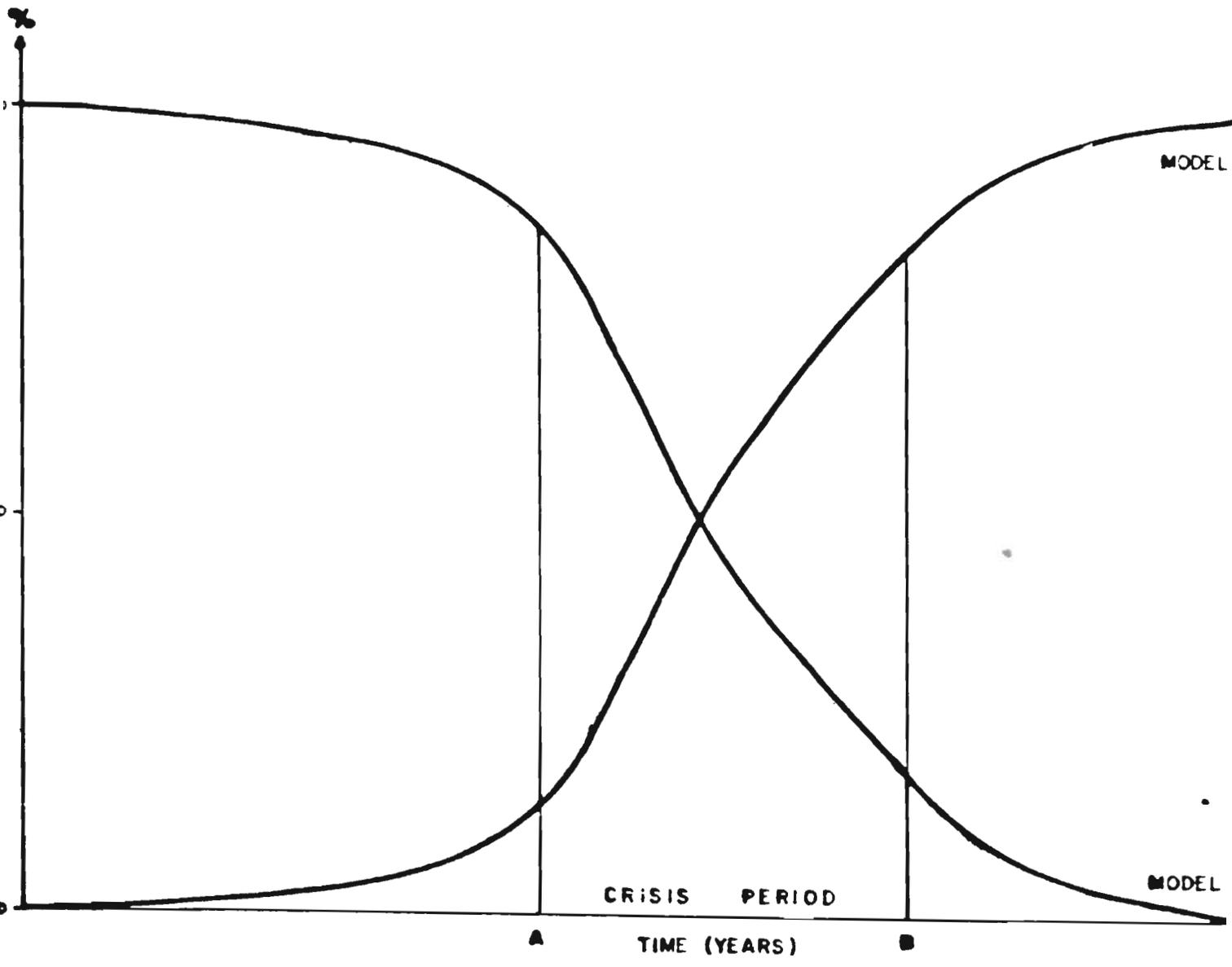
At the beginning, all technologies used by farmers were generated by model A. It starts to lose importance first slowly. Then at a growing speed, when point A is reached. Modernization of agriculture speeds up, and after point B most of the technologies in use by farmers were generated by model B. Eventually a point may be reached when model B is the only source of generation of technology. After point B, agriculture is science based.

The Graphic I indicates the period when stress (or crisis) is mounting. It is located in the interval AB. It coincides with a great acceleration of the modernization process of agriculture. The crisis may be consequence of a food deficit, the loss of the country's ability to export or because rural life is disturbed in view of some farmers are progressing at a faster rate, improving its social status, while the great majority is lagging behind. Or in other words, income is concentrated by the modernization process, and this almost means that land is in fewer hands. The rate of migration speeds up, and if the industrial and services sector do not develop, unemployment and underemployment emerge in the cities, with all of its consequences.

The stress is consequence of the fact that society delayed the investment on research or in the import of technology, if there was technology to import. And the delay brought about the crises, as consequence of the lack of response of agriculture to a growing demand or to the increase of competition in the international markets.

How long the stress will last depends on the ability of society to remove the factor that blocks modernization of agriculture, and lack of investment on research is the main one.

GRAPHIC I: MODELS OF TECHNOLOGY IN USE BY FARMERS



The need to a great increase in the speed of the modernization of agriculture, at point A and after it occurred because the investments were not made in the right amount in the previous period. Hence the crisis can be avoided if the government learns when model A loses the capacity to bring about a supply growth that is according to the growth of the demand, and make the investments that are necessary.

### TYPES OF CRISIS

The crises are classified in the following types which may be present at the same time:

a) Food deficit - It means that the demand for food is growing at a faster rate than the supply of food, and the country is not in condition to import it, because of problems with the balance of payment brought about by a large accumulated deficit in foreign currency. This is the most serious type of crisis, in the sense of causing damages to economic and social systems.

The most important factors that are behind demand growth are population and percapita income increase. Urbanization shifts demand to products like animal protein, fruits and vegetables. Edible beans, manioc and products that take a long time at the home fabric become less and less important. The need to export is another important factor behind demand growth. Among the factors that explain the lack of response of supply are investment in research and extension, price, credit and export policies.

Research institution ought to be able to show to government and society their role in solving food crisis, and hence how important is to increase the investment on them.

b) Loss of the capacity to export. Most developing countries have an important export sector of agricultural products. At the production side, the most advanced farmers belong to it. After the Second World War the developed countries experienced a fast growth of export of agricultural products as

consequence of the modernization of agriculture and huge amount of subsidies provided to it. Since then, competition is mounting; and after 1975 the prices of the most important export commodities as soybean, corn, wheat, sugar, rice and cotton have been decreasing. They have reached levels that are the lowest in modern times.

The developing countries have not been able to face this competition, and, hence, are losing position in the international markets, and some of them are becoming net importers of food or are importing food at increasing rates.

The loss of important markets and the import of food trigger the mechanism of a deep crisis in rural areas that reflects over all society. Income in rural areas decreases and the rate of migration speeds up. The balance of payment worsens up. Society sees in the imports of food a sign of loss of prestige and that the country becomes more vulnerable to the fluctuation of the international trade.

### c) LAND TENURE

The growth of rural population, lack of employment opportunities in other sectors of the economy and the concentration of land in the hands of few people are responsible for another type of crisis that is common in the developing countries: the pressure of the peasants for land. When there is a food deficit and the migration rate is very high society may see in land distribution the main cause of the crisis. And then it comes the quest for agrarian reform as way to modernize agriculture and to reduce the disparities of income. In modern times, the agrarian reform creed sees in research and extension an important tool for the success of the program.

When there is a frontier to expand agriculture, a way out of the crisis is to incorporate more land in cultivation, and this happens at the expenses of investments in the increase of productivity. When research institutions face such situation two courses of action are advisable. First: demonstrate how much society loses because productivity does not increase; and second: show that research is an important tool to solve problems posed by a new environment where agriculture is expanding.

#### d) FACTOR PRICE CHANGE

This change brings stress over the cost of production and farmers react to stimulate the generation of technologies that save the factor that has its price increased more. So the research institutions are induced to shape their research programs according to the factor price changes. It is not only a question of reallocation of funds. The government is also induced to increase the investment on research. The literature on this subject is vast, and the best reference is Hayami and Ruttan (1985).

#### GENESIS OF THE CRISES

The factors that explain the crises vary from type to type of crisis. For instance, the policy to expand the acreage coupled with high rates of migration to the cities and the restrictions of the immigration laws, causes labor to become relative scarce to land and, consequently, shifts the factor prices.

The discrimination against agriculture, which is so common among the developing countries, to foster industrialization, restricted the ability of agriculture to respond to demand increase and caused a growing food deficit, in conjunction with loss of exporting capacity.

The policy to subsidize modern inputs through credit discriminates against small farmers and favors the concentration of land in fewer hands.

If the increase of productivity is the best avenue to increase supply and the government does not support research to the extent that is needed, agriculture loses the capacity to grow and to compete in the international markets.

From the stand point of the research institutions that want to see their funds increased, it is important to know the nature of the crises that are present, and more, to be able to foresee when they start, if they are not present.

## SOURCES OF SUPPLY GROWTH

The identities bellow are well known, and useful to identify the sources of growth. The symbols are annual rates (geometric) of growth.

$$p = a+r + a.r$$

p=production; r=yield; a=acreage

$$a=t+k + t.k$$

t=area that each worker can cultivate; k=labor force in agriculture.

The two identities may be combined to give:

$$p=r+t+k+(r.t + r.k + t.k + r.t.k) \quad (1)$$

The bracket measures the interaction effects, which tend to be small in relation to additive ones.

Production grows by the increase of yield, labor productivity (measured in terms of the area each worker cultivates), and growth of labor force.

To increase acreage it is necessary to have  $t+k+t.k > 0$ . If  $k < 0$  (labor force in agriculture is decreasing) then it is necessary to have  $t > |k+t.k|$ . This means that mechanization must be stimulated.

If  $r=0$ , which was so common among the developing countries up to sixties, production will grow only by acreage increase. If  $t=0$ , which was true also in some developing countries, production growth is equivalent to labor force growth.

If there is a technological barrier to acreage expansion or if the frontier is already exhausted, then  $a=0$ , and  $t > 0$  implies  $k < 0$ . This means that labor is displaced, and the size of displacement varies with  $t$ .

By the decomposition above, there are two paths for output growth ( $p > 0$ ): yield and area increase, and they need not be mutually exclusive.

However from the stand point of costs to society, one may be preferable to the other. If yield is preferable to area increase, and if the investments are made to only increase acreage then  $p$  will be smaller, for a given set of prices and technologies.

In table 1 is the decomposition of the rate of growth of output of Brazilian Agriculture for four decades, starting in 1940-50 decade. It can be seen that acreage increase is the main source of growth, except for the last decade, when yield became the most important source.

Yield increase started at very low level and recently speeded up to become the most important source. The opposite is true for acreage that decreased in the last two decades.

Brazil has about 66% of her agricultural land not occupied by agriculture. The slow down of acreage increase is consequence of the difficult environment where the new frontier is located: Amazon region. Besides, it is expensive to bring it under production, and the operating costs of production is higher there than in anywhere else in Brazil; and to these negative factors, one has to add the transport costs to the important markets of the country, which are far from there. But anyway acreage increase is one of the important sources of production expansion in Brazil, and research institutions need to show to society how they can contribute to solve problems of the new frontier.

TABLE 1: DECOMPOSITION OF THE GEOMETRIC RATES OF GROWTH OF PRODUCTION BETWEEN ACREAGE AND YIELD. DATA FOR THE PERIOD 1940-80. THE RATES OF GROWTH ARE IN PERCENTAGE.

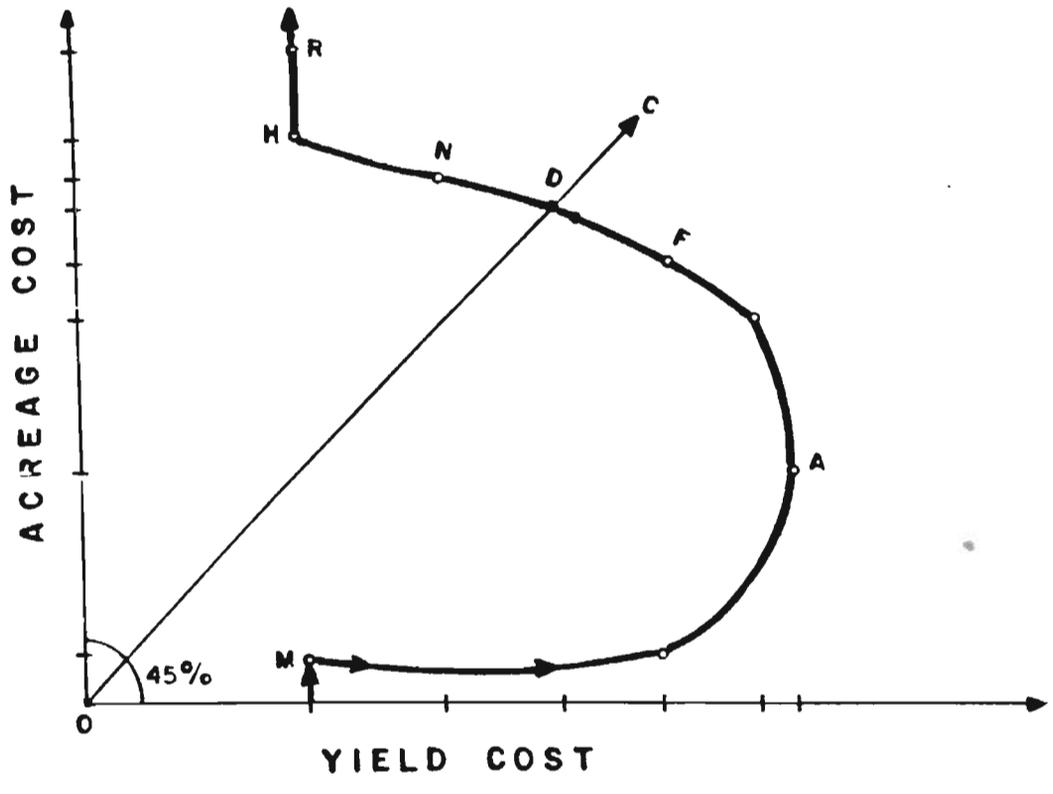
Sources of Growth	DECADES			
	1940-50	1950-60	1960-70	1970-80
Yield (r)	.53	1.58	1.89	3.49
Acreage(t+k)	2.58	4.16	3.46	2.96
Production(p)	3.11	5.74	5.35	6.45

Source: Adapted from ALVES (1984). The interaction effects were small and were included in  $r$  and  $t+k$ .

#### ACREAGE OR YIELD INCREASE

Graphic 2 was built to clarify the conflict that develops between acreage and yield growth as means to increase production. The vertical axis measures acreage cost, and the horizontal one yield cost. The path  $MR$  indicates the social costs to obtain one additional unit of production through yield and acreage. Each point over the path reflects a different date. Time increases from  $O$  on. Line  $OC$  is the locus of points where the two costs are equal.

Graph 2: SOCIAL COST TO OBTAIN ONE ADDITIONAL UNIT OF PRODUCTION BY YIELD AND ACREAGE INCREASE



In acreage are included the usual costs of production, investments to bring land in production, like roads, infrastructure, forest clearing, etc. In yield, are the costs of research and extension, credit subsidies to stimulate the diffusion of innovations, and the usual costs of production.

In the beginning, acreage costs grow slowly for the land that is easier to cultivate and more fertile is firstly incorporated into production. Then it increases at faster rate. The new land is far from the markets, difficult to clear, and there is also the loss of fertility of the older areas. There are many technologies that reduce such costs: transport, land clearing and drainage technologies, etc. They delay the increase of the acreage costs to produce one additional unit of output.

The yield cost grows at fast rates in the beginning. Traditional technologies, model A, has a very limited power to increase yield. The possibilities to import technologies are also very restricted. When the country shifts to model B, and improves its capacity to generate knowledge and technologies yield cost slows down, comes to to a stop, and, eventually, decreases. At point D they are equal. At point A the yield cost starts to decrease, and the rate of decrease speeds up ever since.

Eventually the frontier exhausts, and, hence, there is no peaceful way to incorporate additional areas. This happens at H, when acreages cost grows without limit. At this point yield cost reaches a miminum, and the path becomes vertical.

The convex part of the path MR faces the line OC.

If a country is in a point below line OC, let's say point A, one additional unit of output costs more if obtained through yield than if through acreage increase; Above line OC, the opposite occurs.

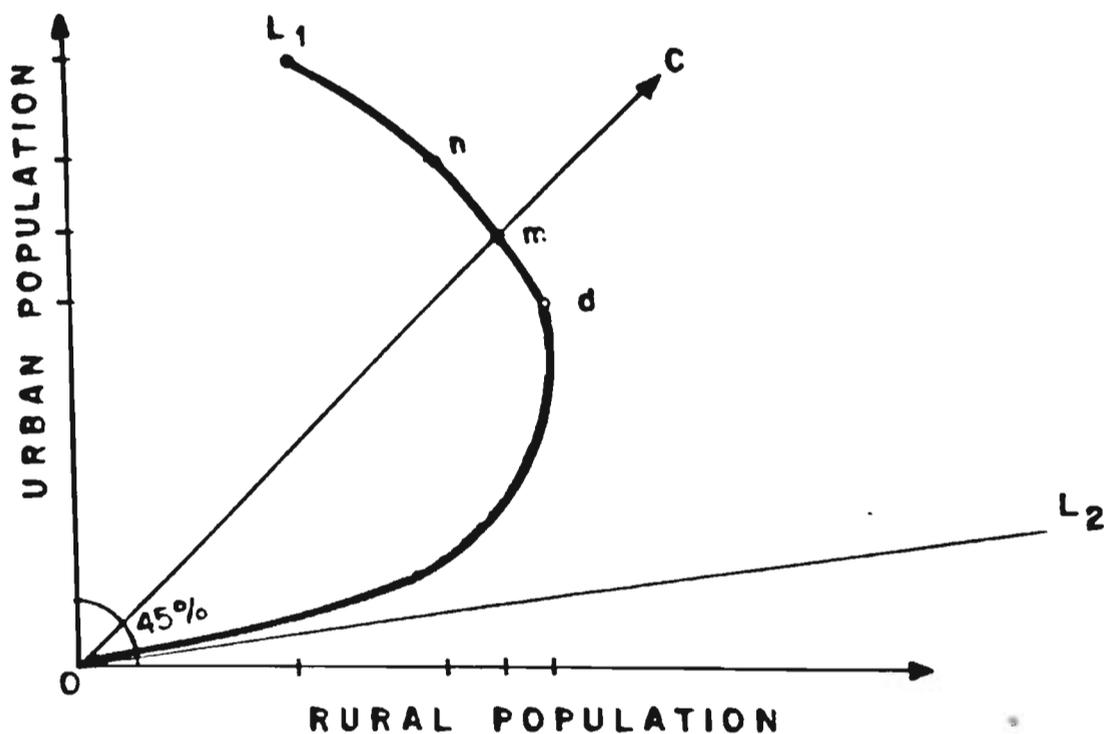
Much before exhausting the frontier, it may be cheaper to increase output by yield increase, and the country may be pursuing an acreage increase policy, which is the most common one among the developing countries. Then the output of agriculture

would grow by a smaller amount, sometimes much smaller, than it would have been if a yield increasing policy was the choice. There are many political pressure for land expansion and very little pressure for yield improvement. The reason are: historically, this is what has was done; hence tradition pushes in that direction; pressures over the land by preasants that want more land to cultivate; the high cost (finantial cost) to establish research and extension institutions, or to expand them; the false idea that research only brings results in the long run (a confusion between research project and research institution-the later produces results every year).

The inadequate policy leads the country to a food deficit, to export less and less, worsening the balance of payment problems and to the impoverishment of rural areas, with the consequent increase of migration. Urban and rural crises are set free. When the line **OC** is crossed, if investments in yield increase were not made previously, the country will be moving toward the crises. It is also important to note that is difficult to convince the authorities to invest on research, when the point reached is below line **OC**. The research institutions established in this period may not survive, because lack of support.

To take advantage of the crises to improve the support to research institutions, is important to know whether the country is urban or not. The strategies varies whether the political power is in the hands of the urban people or of the rural people.

Graph 3: THE GROWTH OF URBAN AND RURAL POPULATION: NUMBER OF INHABITANTS.



The graph contains two paths. The path  $L_1$  is for a country that created employment opportunities in the cities. They were able to continuously attract the rural population. Initially majority of the population was located in rural areas. Migration, sometimes at growing rates, shifted the address of the population to the urbis. At line  $OC$  urban

population equals rural population, and then becomes larger. countries that followed path L<sub>1</sub> pursued also a policy of draft industrialization. The idea of the policies was to apply the savings (internal and external) in the industrial, energy and road construction sectors, and let agriculture grow by acreage expansion, with a very small amount of investment in modernization, to avoid competition for the saving, with the urban sectors. Referring to graph 2, points above line OC were reached, before the agriculture policy shifted to yield increase.

When line OC is reached, the political power also shifts to the cities - to the hands of the leaders of the industrial and financial sectors and organized labor, which are political groups with the same interests. They are important targets to obtain the support for research. It is important to give them conditions to understand that the urban crises will worsen up if the agriculture policy does not shift to yield increase and that it cannot be achieved without investments in research.

The themes to discuss are the following:

- a) linkages between violence and food deficit;
- b) reduction of worker productivity and ability to learn as consequence nutritional problems;
- c) loss of the capacity to export;
- d) Increase of migration as consequence of income problems in rural areas;
- e) The need to import food and its devastating effects over the balance-of payment and the moral of the country;
- f) The worsening of equity problems as consequence of the increase of food prices.

The methods to reach the targets groups must be effected by competent professionals, hired from the press. Television, newspapers of wide circulation and radio must be used. The message should interest the urban population, but not to the neglect of rural people. On the contrary, one should stress the role of farmers in solving the urban crises (Alves, 1984).

Path L<sub>2</sub> is for a country that preferred to stay rural or that could not industrialize. The leadership of the country is predominantly rural or has strong interests on rural areas, where are located the sources of political power.

It is necessary to take into account two groups of countries. The first is densely populated and the frontier is already exhausted. They have a long tradition with agriculture. A culture built around religious feelings. The grasping of the meaning of the world and of things is from the general to the particular. Reasoning is much more intuitive than analytical. It not ease to create an environment favourable to science, and let science impregnate the whole society. This is, sometimes, done by means that are not democratic, which may work or not, and most of the times do not work.

They are poor countries. The level of savings is low. The investment in research institutions needs the support of the donor community. Hence to show the relevance of research it is important not to overlook the donor community. The opposite mistake should be avoided: the neglecting of the possibilities of internal financing.

One need to be careful not to present science as opposed to religion. To avoid, be it implicit or explicitly done, comparisons between scientific and religious reasoning.

The themes to be discussed are linked to poverty problems, famine, well being and the role that modern agriculture has to improve income in rural aereas. In those societies, the question of equity is a major issue, and, hence, shoud be addressed carefully. The press, churches, meetings with important leader are the main communication channels with society.

The second group of countries has not yet exhausted the frontier through which agriculture can expand. However, the frontier presents problems to agriculture production or may require huge investments to become productive. This is a theme to discuss, and also how science can be helpful to develop the

frontier land. One need be careful to analyse the problems that may exist to have science accepted by society. Farm people in ever situation tend to be suspicious of the paradigms of science.

### SIGNS OF CRISES

It was analysed four types of crises: food deficit, loss of export capacity, land tenure and factor price changes. Simple minded statistics gives evidences for them. The growth of output ( $p$ ) can be computed, also yield and acreage. The identity below is true, for each period:

$$p = r + a.r$$

$a$  = annual rate of growth of area (geometric).

If there are statistics of the labor force, identity (1) can be applied. Yields can be computed on a crop by crop basis. With this approach one loses the effects of crop substitution on yield. These evidences show whether yields are stagnated or not, and what is the contribution of acreage to output growth; and, finally, how the contribution of acreage splits into labor productivity and labor force increase.

What is much more complicated is to evaluate whether line OC of graphic 2 has been crossed. In other words, where the return to investments is higher: acreage or yield increase? Statistics on the rate of return of research and extension provide some hints. But the best is a direct evaluation of the return of investment in acreage or yield growth. The literature is lacking in this respect.

### CONCLUDING REMARKS

It was shown how crises can be helpful to obtain support from society to research. The ideas discussed are very general, so that they can be broadly applied. A given research institution, however, should find out the best strategy that suits it. The point to be stressed is that the support for research institutions can be increased if the correct strategies are chosen, and this involves the discussion of broad economic and social issues.

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