NOTES ON DISSEMINATION OF NEW TECHNOLOGY

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INTRODUCTION

Brazilian agriculture in recent years has received considerable support from the public sector. One of the primary policy tools has been the increasing financial support for research and extension. This paper deals with relationships between dissemination of new technology, production systems, agricultural research and extension activities.

Questions are raised which have been under discussion since the origin of rural extension in 1948. The dissemination model, which is the operational basis of the Rural Extension Service under the leadership of EMBRATER, is reviewed; some problems in dissemination of technology are discussed.

AGRICULTURAL PRODUCTIVITY

Productivity indices express the relationship between the product and the inputs used in its production. These may be of a partial or a cumulative nature. In the case of agriculture, the indices most studied concern production per area and production per worker. An alternative way of measuring labor productivity is: the index of area cultivated per worker. An increase in this index shows that each worker is capable of cultivating a larger area. In this way, its increase indicates the degree of use of mechanical technology.

The aggregate productivity index (total production divided by total input) is a more adequate measure of productivity gains. Increases in this index indicate that fewer resources are being utilized for the production of a product unit. It is difficult, however, to calculate, since historical records are not available in Brazil.

An increase in the productivity index per area indicates that less land is necessary for the production of a product unit. This may occur, however, through the use of resources which are wasteful to the economy; in other words, this index can grow while the aggregate index is falling.

An increase in the production index per worker is a sign that a smaller number of work units is needed to produce a product unit. Since it is a partial index, the same exception must be made for the productivity index per area.

A comparative study of countries, which have been successful in modernizing their agriculture, indicates that two predominant approaches have been followed. In those countries in which the price of land increased relatively more than that of salaries in the agricultural sector, the production index per area had the greatest increase; in countries in which salaries increased relatively more than the price of land, the opposite was noted. The area per worker index was the one which increased most as a result of agricultural mechanization. Japan is an example of the first case, and the United States of the second.

TABLE 1. Production growth rates per hectare of arable land and arable land per worker: United States and Japan. Data in percentages.

Items	Period	1880 to 1890	1890 to 1920	1920 to 1940	1940 to 1960	1880 to 1960
Production per hectare	United States	-0.5	-1.1	1.4	2.1	0.4
	Japan	1.6	1.5	0.6	1.5	1.3
Arable land per worker	United States	1.6	1.7	0.8	3.7	2.0
	Japan	0.6	0.7	1.0	0.1	0.9

Source: Hayami & Ruttan 1971, p.115.

Data for Brazil is not available for such a long period. Everything indicates, however, that the road to agricultural modernization more closely approximates that of the United States than that of Japan. In addition, productivity growth rates for land stand out in the regions in which greater investments were made to create chemical-biological technology. In the Northeast, labor productivity, measured in terms of area per worker, increased.

TABLE 2. Annual agricultural production growth rates and their sources. Brazil and regions. Periods: 1950-60 – 1960-68. .

Growth components	Regions	Growth rates in %	
		1950-60	1960-68
Production per area	Brazil	1.77	2.03
	São Paulo	3.76	4.79
	Center-South	1.55	2.09
	Northeast	0.48	0.62
Area per worker	Brazil	0.54	1.96
	São Paulo	-0.06	0.62
	Center-South	1.62	1.99
	Northeast	0.16	3.14
Manpower	Brazil	3.53	1.36
	São Paulo	1.21	-1.32
	Center-South	3.39	1.68
	Northeast	4.39	1.65
Agricultural production	Brazil	5.84	5.35
	São Paulo	4.92	4.09
	Center-South	6.56	5.76
	Northeast	5.03	5.40

Source: Pastore, Alves & Rizzeri, p.259, Table 1.

Since the evidence shows that productivity growth is made in relation to the relatively scarcer production factor, comparisons of productivity of land, or of labor between countries, or between regions within a country, prove little unless similarities in factor endowments are taken into consideration.

It is seen that countries with an abundance of land have a low productivity for this factor – the United States, Brazil and Australia. Those countries, having a shortage of land, Japan and France, show high productivity for this factor. The same is true in relation to manpower. This does not account for the low indices of Brazilian agricultural productivity; it only shows that factor endowments exercise a decisive role in determining productivity levels.

MODERN AND TRADITIONAL AGRICULTURE

It is beyond the scope of this study to enter into the intricacies of modern

TABLE 3. Land and labor productivity estimates in agriculture, 1960 in wheat equivalent units.

Countries	Production	
	Per hectare	Per worker
United States	0.80	99.5
Japan	7.47	10.7
Brazil	0.60	9.4
Argentina	0.37	39.9
France	2.02	30.9
Australia	0.09	106.4

Source: Hayami & Ruttan 1971, p.70.

and traditional agriculture. However, to have some idea of the market differences from the point of view of resource allocation procedures, there are no marked differences between the modern farmer and the traditional farmer. By all indications, both attempt to maximize the use of available resources.

On the production side, a smaller portion is destined for the market by the traditional farmer who consumes a substantial portion of his production.

From the production factor side, traditional agriculture uses land and labor. Little is invested in recovering soil fertility, either through the purchase of fertilizers, or by the production of substitutes, such as green or organic fertilization.

In modern agriculture, the farmer sells almost all of his production. In the composition of costs, inputs bought from urban sources play a major role. With the petroleum crisis and the subsequent increase in the prices of modern inputs, everything indicates that the production of inputs, at the farm level, has again become important; this occurred in England in the XVIII and XIX centuries. Present examples of this are cases of integrated pest, disease and weed control, green manure, nitrogen fixation by irrigation, soil conservation, etc.

Modern day agriculture consists of two sectors: one whose production is meant for selling, and the other whose production is dedicated to maintaining or increasing soil fertility and to combating pests and diseases of plants and animals. It is obvious that a high level of business transactions will continue between the agricultural and other sectors of the economy, both at the product and at factor levels.

RESEARCH INSTITUTIONS AND THE DISSEMINATION OF TECHNOLOGY

From the research viewpoint, the production of a new technology cycle can be characterized in the following way:

Difficulties encountered by farmers, and considered by them as serious problems, without appropriate solutions or on-going work at the research level, are identified and analyzed by the researchers in the light of learned theories. In this way, research projects are born. These lead to the formation of hypotheses and to formulation and implementation of experiments whose outcome comprises fragmented research results. One part of these results, such as new crop varieties, animal breeds and superior insecticides, have a physical existence, while the other part constitutes a set of recommendations on how to better use existing or newly developed inputs.

The partial, or what are often referred to as fragmented research results, are brought together in the form of "technological packages", and form the new technologies which will be offered to the farmer for adoption. Thus, research is an industry which produces technology, while extension adds an information content to newly developed technologies, making them accessible to farmers.

New technologies are the aggregate products of research, while the contribution of extension institutions is the information which is added to the new technology to create a message comprehensible to the farmer. Under Brazilian conditions, this message contains additional information on credit policy, minimum prices and agricultural insurance (PROAGRO), all of which play an important role in the farmers' decisions to adopt or not adopt the new technology.

Just as various industries do, both research and extension consume inputs and produce outputs. Their efficiency must be measured in terms of inputs consumed and outputs produced. It should be pointed out that the output of a research system cannot be separated from the contribution made by extension. When the technology reaches the farmer, at which time its economic and social efficiency can be measured, the work of the two institutions is complementary. For this reason, it is often said that the development of agricultural technology is a "continuum" which begins with a problem of the farmer and ends when he adopts at least part of the technology developed.

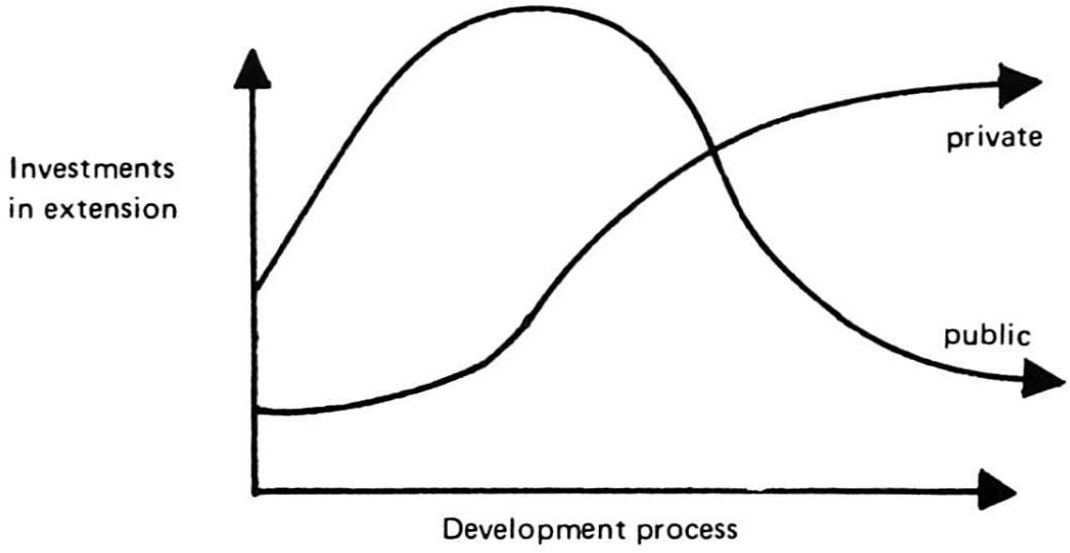
RELATIONSHIP BETWEEN PUBLIC AND PRIVATE EXTENSION

In all stages of the economic development of agriculture, the "technology

dissemination" function will always be present. This presence is more intensive when agriculture is more dynamic. What may vary is the nature of the institutions which execute this function. In the more advanced countries, private institutions predominate, while the situation is reversed in the developing countries. This occurs because the greater investment in formal education in the advanced countries makes farmers much more capable of decodifying by themselves and judging the messages produced by research, or by firms which sell modern inputs.

In countries where farmers are accustomed to technological change, private extension services may be able to increase production and foster economic growth, since private modern agricultural input and equipment-producing firms produce information related to their own product, similar to public extension.

FIG. 1. Private and the public investment in extension during the development process.



In the advanced countries, the tendency still persists for public extension institutions to give greater attention to more needy farmers. The poor farmers, with little education, need help which is very costly for private firms, which consequently discriminate against them. If the government does not provide appropriate technical assistance, they will remain outside the agricultural modernization process. Income distribution problems will be aggravated in rural areas as will rural-urban migratory movements. In the case of Brazil, there is another aspect to be considered. Small farmers are responsible for producing the greatest portion of food consumed by the poverty – stricken portion of the urban population. If they fail to modernize, there will be additional negative reflexes on urban income distribution due to increasing prices of basic food items.

Those who are acquainted with the history of the Brazilian Rural Extension Service – which is represented today by EMBRATER, as the institutional leader on the federal level – know that until about 1964, this Service dedicated the greatest part of its efforts to the small and medium farmer. There was a strong influence in this activitv of ideas originating in the American system which, for a long period, dedicated most of its attention to the poorer segments of agriculture. From that date on, there was a slow change of orientation in the direction of the medium and large farmer. The reason for this change appears to be rooted in the necessity for increasing the production surplus for the urban sectors and for export. It was realized at the time when the change in orientation took place that the medium and large producers had a greater response capacity, either because they had more idle resources, or because of their greater capacity to assimilate new techniques.

In the period beginning in the 1960's, many changes took place in agriculture and in the sectors which purchase its products and sell it inputs. The same thing happened with the channels of communication, with farmers having greater access to radio, journals and television. This was especially true in the Center-South region. For this reason, it is natural that the space occupied by public rural extension was partially reserved for private technical assistance in the case of medium and large landowners. In the Northeast, the need to give more assistance to small farmers is evident. From now on, we will see a return to the ideas which prevailed before 1964.

THE MISSION OF EXTENSION

The principal mission of extension is to decrease the cost of information and access to new technology. Decrease in cost could be achieved by the following:

a. **Shorten the Time of Dissemination of New Ideas and Tecnologies** – Between the development of a new technology and its adoption by the farmer, the time elapsed would be much greater, if he did not have at his disposal specialized institutions for the dissemination of new ideas, new inputs, improved production systems and relevant information on credit, prices, insurance and marketing opportunities. A longer time lapse in access to new technology represents a cost to the farmer and to society in the form of lost potential income.

b. **Shorten the Time Needed to Make Decisions** – Extension activities shorten the time to make decision, even if the farmer learns rapidly of the existence of a new technology, he will have difficulty in evaluating its

economic consequences. If the risk aversion hypothesis is true, the farmer will only decide to adopt the new technology if it promises a higher profit margin.

Extension can show, in some cases, that the new technology that is being introduced involves less risk than the farmer believes. In these cases even though new technology does not provide higher profit if it represents less risks than the existing one the farmer will tend to accept it.

c. **Clarify Technical Details** – The farmer will, in some cases, encounter problems because of technical details. In certain cases, these details will affect the results, and if they are not followed closely the effort will very likely end in complete failure. In this way, public technical assistance represents a large cost reduction for the farmer, even though the society is paying for it.

d. **Train Farmers and Farm Labor** – It is well accepted in literature on agricultural economic development that in its early stages education of the farm worker has little influence on his productivity. With increased development, as the decision process becomes more complicated and technology more sophisticated, farm workers' education and training become limiting factors.

The public sector, by providing better training for farm workers and cooperating in shaping agricultural institutions to the demands of a better qualified labor force, will enable the farmers to substantially reduce their operating costs through an increase in labor productivity. Institutional setting such as land tenure, labor relations and farm worker compensation system will involve so as to adjust to a better trained labor force and a more equitable division of the benefits resulting from technical progress.

e. **Encourage the Use of Modern Farm Management** – Farm management and rural administration was strongly emphasized in the 1950's and into the mid-sixties. This emphasis has decreased today, and little effort is being devoted to teaching farmers the principles of farm management. It is once again time to teach this science, formerly one of the strong points of extension work, since much waste is observed in the use of labor, machines and equipment, and in other production factors, which substantially affect the farmer's profit.

f. **Explain Current Agricultural Policy to Farmers** – Agriculture policy

created a diverse range of financial instruments; some are of benefit to farmers and others are not, particularly in the long-term. Extension has an important role to play in communicating in a language which farmers can understand, not only the philosophy of agricultural policy, but how best they can benefit from it. There are certainly substantial losses in profits due to the fact that farmers do not use, as well as they might, the advantages offered to them by public and private institutions.

It is well known that extension institutions render other services to the community. For example, they also have an important role in all phases of the research program. They help to define research problems and to conduct experiments, to interpret the results of research and to define technological packages.

COMMUNICATION MODEL

Before the arrival of Rural Extension in Brazil in 1948, some of the extension activities were performed by a development agency which had the strong backing of the federal and state governments. This agency slowly lost momentum and was replaced by the Extension Service whose ideas permeate the entire diffusion of technology scene in the country today. The system is based on state institutions, and is at the same time financed by the Federal Government, which maintains coordination through EMBRATER (Brazilian Technical Assistance and Rural Extension Organization). SIBRATER (Brazilian Technical Assistance and Rural Extension Service) is an institution adjusted to the spirit of the federation. Working together, the federal and state government contribute to the modernization of agriculture, speeding up the dissemination of new ideas.

The characteristic which differentiates the Extension Service from "fomento" is the theory of communication which orients its activity. The principal assumptions and characteristics of this theory are the following:

a. **Capacity to Learn** — Farmers are capable of learning, even when illiterate.

b. **Specificity of Message** — The technical message should be adjusted to the needs of the public to whom it is directed, whether directed to the individual, to the group, or to the masses. The more intensive and diversified the various methods used, the faster is the diffusion of a new idea.

c. **Teaching by Doing** — Teaching by doing is the most effective manner of

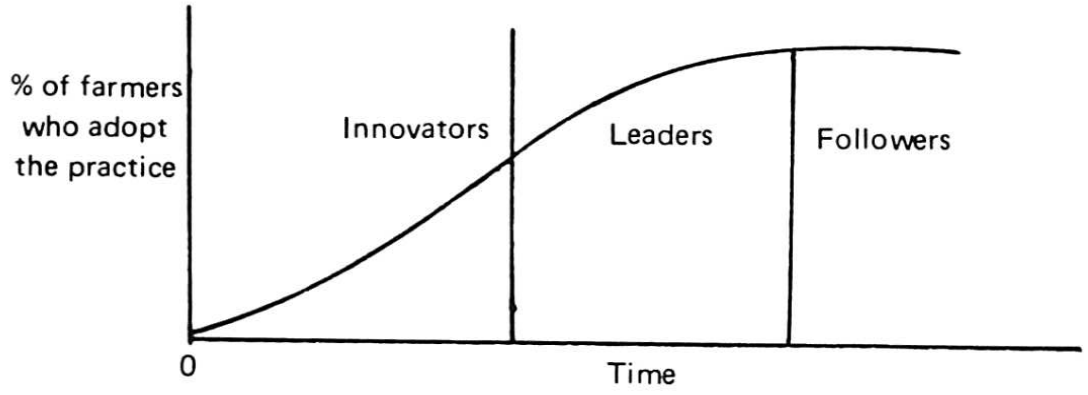
motivating and convincing farmers. Because of professional bias, they believe much more in what they see than in what they read or hear.

d. **Importance of Profit** – The farmer is indifferent to whether the technology is new or rutine; what is important to him is the expected profit.

e. **Learning Step by Step** – Farmers learn step by step. A new idea attracts their attention. They become interested. Later, comes the desire to know more about it. They become convinced of its advantages. They put it into practice, i.e., they try it. Next, they adopt it or they reject it. The literature of the decade of the 1950's shows that public extension had a great influence up until the convincing stage. From then on, private extension was more important.

f. **Diffusion Model** – Figure 2 is a simplified version of the diffusion model. It divides the farmers who adopt new practices into: innovators, leaders and followers.

FIG. 2. Simplified model of the diffusion process.



1) **Innovators** – The innovators are generally alienated from the community. They are richer and have greater mobility as well as a desire to take risks. They are the first to adopt new ideas. But because they are "so different", they have little ability to influence the mass of farmers.

2) **Leaders** – A small number of farmers exercise influence over other farmers and have the ability to encourage or discourage the diffusion of new ideas. These are the leaders, similiar to the great majority of farmers, except in their capacity to learn quicker and to influence

people. For this reason, an effort must be made to identify them and make them change their attitudes so as to accept new ideas. Once this is done, the diffusion of technology process is accelerated and soon reaches the majority of the farmers in the community.

3) **Followers** – These are traditional farmers who only accept a new idea after seeing the neighbor's success; they do not run risks. It is seen that when a new idea is accepted by the leaders, the rate of diffusion of new ideas is speeded up.

g. **Importance of Direct Contact with Farmers** – Rural extension is commonly considered as a bridge between research and the farmers. It seeks technical innovations in research institutions, adds an information content which makes them accessible to the farmers and disseminates them in rural areas. It identifies the problems of the farmers and puts research to work in order to find solutions.

In reality, this idea is an overly simplified interpretation of the American Model. In the United States, just as in Brazil, researchers would never accept separation from farmers. They need this contact because the extension worker, when seeing a farmer's problem, makes his own interpretation (without considering research implications) based on the technical and practical experience he has accumulated. This interpretation may be different from that which a trained researcher, who has had the opportunity to have contacts with farmers, would make before formulation of research projects.

The important point to be made is that researchers and extension workers must work closely with each other. The researcher goes into the field not only to learn about problems, but also to help the extension workers to identify them. This collaboration will help the researchers in the definition of research problems, in conducting experimental trials at the farm level, and even in the interpretation of the results.

Complementary Features of Improved Technologies

Initially, there was a great emphasis on the diffusion of isolated practices, or those with partial results. The idea behind this procedure was that the farmer utilizes a production system and that it is always possible to substitute one of the parts of the system without the necessity of changing others. This is true in many

TABLE 4. Simplified model of two alternative production system using two inputs (1979 prices).

Items	Input price to the producer	System 1	System 2	Restrictions
Land (ha.)	Cr$ 500 ha*	1	1	25 ha.
Labor (man-days)	Cr$ 150 day	30	20	600 man/days
Corn production (kg)	Cr$ 4.00/kg	1,800	1,300	-
Productivity of labor kg/man-day	-	60	65	-
Productivity of land kg/ha	-	1,800	1,300	-
Net income/ha.	-	2,200	1,700	-

* Rent of land.

4) Restrictions: a maximum of 25 ha. and 600 man days are available.

Possible choices:

a. When System 1 with the greater net income is chosen: the 30 ha. cannot be planted. Labor will be lacking. It will take 900 man-days, and only 600 man-days are available. The choice is compatible with planting 20 ha. (600 ÷ 30 = 20). The other 5 ha. will remain in fallow. The total net income would be Cr$ 44,000.00.

b. When System 2 – the one with the smaller net income is chosen: labor is available to use 30 units (600 ÷ 20 = 30). But in this case there would not be enough land. The total available land (25 ha.) will use only 500 man-days. There would be an excess of 100 man-days. In our example, this excess would devote itself to leisure. The net income would be Cr$ 42,500.00.

c. Let us now assume that 10 units (ha.) using System 1 and 15 units (ha.) using System 2 are used. The net income would be Cr$ 22,000.00 plus Cr$ 25,500.00, making a total of Cr$ 45,500.00. This net income is larger than in the first two cases. By the terms of available alternatives, this is the best choice. Table 5 shows a summary of the decision-making process.

Obviously the results would not be valid if restrictions did not exist. But this would be the same as the introduction of other packages. For example, leisure hours would be used on another property. The 5 ha. left over would be planted with another crop. When labor was lacking, it could be obtained through

the labor market. In practice, more production factors are used, with heterogeneous land and with a labor market and financial system functioning. But in actual practice, the possibilities are greater that the highest net income solution will result from a combination of production systems and not with the choice of only one.

TABLE 5. Summary of the decision-making process.

Items	System 1	System 2	Combined system (10 ha. - System 1, 15 ha. - System 2)
Land used	20 ha.	25 ha.	25 ha.
Land not used (in fallow)	5 ha.	0	0
Manpower used	600 man days	500 man days	600 man days
Manpower not used	0	100 man days	0
Net income	Cr$ 44,000.00	Cr$ 42,500.00	Cr$ 47,500.00

This example serves to illustrate the problem which exists with the demonstration of results (or, in this case, the demonstration field) of a complex production system. It is possible that the one demonstrated is not the best solution, at least for some producers. As a matter of fact, every farm proves the existence of combined alternative production systems. If there was a "better" complex, the trial and error process would lead all the producers of an area to choose this complex. As this does not occur, there is a great variation from one farm to the next in regard to organization of the enterprise even when a similar production pattern exists in a given region.

As already indicated, the ideal production system does not exist. One can, however, determine a comprehensive production system which has many positive characteristics and a few negative ones. These kinds of production systems have a good chance of being adopted by the farmers. It is difficult for a scientist to accept these ideas! After all, he is always looking for the optimum. Consequently he has to accept a relative improvement. It will be relative in terms of exising production systems and the market forces within a limited time dimension. It is obvious, that in addition to the production systems identified by research, it will always be desirable for extension workers to learn to modify and adopt these systems. They can act alone in the case of minor changes. Radical changes should be made through consultation with research workers.

Some Initial Difficulties

The Communication Model is very much oriented toward the farmer or the community. It is a difficult problem to introduce a new idea into a community with very little contact with the outside world, and where customs and leadership are very firmly established.

The problem results from the assumption that an available, lucrative technology exists independent of the manipulations of economic policy. Dissemination is not possible because problems of communication exist between technicians and farmers. It is true that these situations sometimes exist but not to the degree often claimed. In the case of lucrative technologies such as soybeans and poultry, dissemination was very rapid and communication problems were easily resolved. In the case of poultry, the producers were substituted: the backyard poultry producer was replaced by the modern large scale poultry farmer; in the case of soybeans, if any substitution took place, it was less intense.

Negative results obtained led to a redefinition of the problem of agricultural modernization. It is obvious that the "dissemination of a new idea" function is important and much is expected of this function in an advanced agriculture. But in order to be successful, dynamic research institutions and an economic policy which does not discriminate against agriculture, reducing prices of products and increasing those of modern inputs, must exist. Besides research and extension and a correct economic policy, rural credit institutions and those interested in the ownership and use of land, cooperatives, schools, etc. must be developed. However, agricultural modernization is a complex task which is far beyond the possibilities of a good Rural Extension and Technical Assistance Service; but, seen another way, this modernization can not take place without the presence of this Service.

In the 1950 and 1960 decades, a strong bias existed in favor of investments in the dissemination of technology and in silos, warehouses and roads. The idea predominated in this period that a stock of knowledge existed at the disposition of researchers and the only thing lacking was to disseminate it. On the other hand, losses from the marketing process were very high and an easy way of increasing the supply of food was to reduce these losses.

In the 1970's, it was realized that in the case of the majority of crops, livestock projects and regions of the country, the hypothesis on the existence of a stock of knowledge was false since very little was invested in research. Research results are specific as to site and, as a result, the possibility of transfering them from the advanced countries to Brazil or from one region of the country to

another, are low. It also became obvious that the reduction of marketing losses is much more complicated than it appeared at first sight. This could not be done without modernizing agriculture.

Brazilian agriculture policy has attained a greater degree of maturity. The role of each instrument is better understood, and above all, it is known that productivity will only increase in a self-sustaining manner if adequate investments are made in knowledge producing institutions which will create the necessary scientific basis. Without this scientific basis, there will be nothing to disseminate. Without technology dissemination, the scientific basis created will become sterile. Scientific achievement will fill pages of scientific journals and will impress foreign visitors, but will not reach the hands of the producers, as alternative technologies to those in actual use.

Another important aspect which should be stressed is the tendency which exists for the more enlightend and mobile class of producers to go directly to sources of knowldege production for the alternative technologies which they need. It is common for this class of producers to help themselves to information at the source level because they consider themselves capable of interpreting the results. To prefer to obtain information directly from those who created it, certainly is a more secure manner for discussion of research data. Researchers are benefitted by this pressure from advanced producers. It stimulates them because it gives them the pleasure of seeing their work being appreciated by a part of their clientele. It represents an opportunity to check technical details of the new technology proposed and to verify its negative points. The contact with producers represents an opportunity to become aware of new research problems.

There are, however, two problems. On one side, if the contact of the researchers is limited to the class of producers mentioned above, the research program may exclude the necessities of the lesser favored groups. On the other, an organization of work is needed which facilitates catering to the producers. The presence of extension workers on the bases of research would help to resolve this difficulty in addition to offering other advantages.

Formulation of Improved Agricultural Production System

Improving agricultural production system can be best visualized through the following concepts:

a. **Communication Model** — The Communication Model contains the following components (1) a source of knowledge (2) the communication

media through which the ideas generated by this knowledge are transmitted (3) the target population in this case the farmers that receive the information and (4) the consequence or the impact of these informations.

b. **The Universe of Knowledge** — At any given moment there is a body of knowledge which can be divided into two groups: (1) "systematized" knowledge, or that which can be deduced from the basic principles or theories (2) the knowledge which has not yet been systematized. It is waiting for the formulation of an appropriate theory to unify it.

Let us call the complex of knowledge a "universe of knowledge". The role of both basic and applied research is to increase the knowledge universe. Basic research has as its fundamental role an effort towards systematization. Applied research has as its role the development of new information even though it is not possible at the moment to relate it to a body of fundamental principles.

c. **Production Systems** — The process of technological change in agriculture is the result of interaction between the Universe of knowledge and farmer's production systems.

The universe of knowledge gives origin to a wide variety of production systems. These systems represent the embodiment of knowledge in a series of practices used by producers. In this way, every production system is the "realization" of a parcel of knowledge which forms part of a universe of knowledge. In reality, a production system is formed from two distinct components: a series of inputs and a set of rules on how to combine the inputs, both derived from the universe of knowledge.

The universe of knowledge, as was pointed out, gives origin to a wide variety of production systems. One must, however, learn to evaluate and classify these production systems. The evaluation and classification can be done in terms of increasing profitability and diminishing risk. Measuring profit can obviously only be done by simulating the decision-making process of the farmer. To do this, one must consider risk, environmental factors, available markets, etc. In fact, the ideal production system is a fiction; it does not exist, even if one greatly simplifies reality. One can, however, identify production systems which have many advantages and a

few disadvantages. Depending on the circumstances, extension can facilitate adoption of one of these systems by a community of farmers.

According to this reasoning, the role of research is to increase the number of production systems. Thus we will be giving the farmers a greater choice which will permit each one of them to make the better choice, considering the markets, the characteristics of the properties, his patrimony, his personality, etc. It is very difficult for a scientist to accept these ideas! After all, we are are all looking for the optimum. But, unfortunately, we have to accept a relative optimum — in this case, relative to the property and to the market forces within a limited time dimension.

At the present stage it is impossible to indicate the "best production system" for each property. There are neither resources nor knowledge for this, especially those regarding expected prices, both in the internal and external markets. The available alternative is to prepare a wide range of production systems and let the farmer, with the help of extension workers, make the choice. Some people suggest looking at the whole universe of knowledge and, starting from this point, the extension worker would help the farmer to create the production system most appropriate to the goals he has in mind. This is an illusion! No profession works this way. It is obvious that in addition to the production systems created by research, it will always be desirable for the extension workers to learn to modify them. This should be limited to small changes. Radical changes should be made in consultation with researchers.

Agricultural production is a complex phenomenon with hundreds of individual tasks and use of scarce resources distributed over time. Each task can be performed in several distinct ways with an implement power combination and a set of inputs. Choices among these many tasks are enlarged when new implements, power sources and materials are introduced as a result of technological change and innovations.

d. **Negative and Positive Interactions** — The production system comprises a set of practices. The makeup is determined by the desire to minimize negative interactions and to maximize positive ones. The systems compatible with this criteria should be chosen, put to special tests and evaluated by the farmers and extension workers. These will comprise the list of production systems which will be used by extension organizations. Each production system, in addition to the inputs, practices and rules governing its makeup, should also contain a list of counterindications or its weak

points. If a planting date is indicated, it should furnish production loss estimates, which will occur if this date is not followed. It is the same as counterindications provided with any medicine. The shortcomings of each system are easier to obtain when the production system is submitted to a rigorous test.

Evaluation of Improved Agricultural Production Systems

In testing the new production system, the principal objective is not to reject or accept a system, but to characterize its strong and weak points, and the risks involved, when the recommendations are not respected. This information is indispensable to the farmer in making decisions. Production systems should be evaluated in two stages:

a. **Experiment-Station-Level Evaluation** — The first occurs at the experiment station level, where new production systems are submitted to adverse and favorable conditions, in order to determine their positive and negative characteristics. Automobile factories have special test tracks to test new models. It is clear that research needs something similar before turning over new production systems to the farmer. The "research test tracks" are obviously much more complicated to construct. A large number of factors concerning the environment, the farmer, markets, etc., must be simulated. As a mater of fact, this is an area deficient in research, and therefore represents a priority area for potential studies by rural economists.

b. **Producer-Level Evaluation** — The other stage is carried out at the level of the producers who are using the recommended production systems. The definitive test is made there. The same is true of cars; only different traffic conditions can offer definitive tests.

The changes in input-output price relationships will change producers' preferences for productions systems. The most lucrative ones can become less profitable, and the least lucrative more profitable. For this to happen, an economic policy favoring modernization of agriculture has a decisive role to play, since it is capable of retarding or stimulating the process, depending on the way various policy instruments are used.

The Nature of Benefits Generated by Research

Agricultural research often constitutes an investment in which private profits provide only an incomplete or indirect indication of economic return.

In most countries which have been successful in achieving rapid rates of technical progress in agriculture, public sponsored agricultural research has been deliberately employed as an instrument of modernization in agriculture. Its diffusion was regulated by public credit and information institutions and by price and trade policies.

The results of agricultural research in the form of improved agricultural production systems, in terms of potential social and private benefits, can be divided into four groups:

a. **Improved Agricultural Production Systems Resulting in High Private and Social Benefits** — These systems offer both higher private and social benefits compared to the system being used. They are beneficial both to producers and to society in general. Diffusion of these systems is relatively easy and cheap. The various technical components of these systems are separable and can be gradually integrated into prevailing systems.

b. **Improved Agricultural Production Systems Resulting in Low Private and Social Benefits** — These systems have little or no benefits either for the producer of for society. They will not be adapted by farmers, and the only solution is to have research and extension workers reformulate them or avoid their diffusion, until existing economic or environmental conditions change, so as to make these systems beneficial.

c. **Improved Agricultural Production System Resulting in High Private and Low Social Benefits** — These systems are easy to spread since they provide immediate benefits to producers. In the case of systems where private benefits are significantly lower than social cost, such as highly polluting pesticide activities, research and extension should provide information to discourage their use.

d. **Improved Agricultural Production System Resulting in Low Private and High Social Benefits** — These systems and the technologies that were used to formulate them, need government action to internalize some of the social benefits, making them profitable from the point of view of individual producers. These systems usually have a high initial cost to the producers, such as equipment and land preparation, in the case of irrigation. Other examples are improved seeds that have a relatively high initial investment for seed producers, that may not be recuperated by producers in the first year, and that are not protected by any patent rights for subsequent years.

This classification follows a general rule of all extension work according to which the new technology to be offered by extension must be biologically feasible, economically profitable and socially desirable.

The classification of production systems given above implies that it is not enough only to create new technology; there is a need for supplementary government programs to be included in development policy, without which the diffusion of new technology becomes very difficult, if not impossible. Questions of legality, and ownership, patents, etc. play an important role. Difficulties such as the legalization of land holdings and short-term, rather than long-term renting arrangements, discourage long-term investments in land. The existence of high inflation and high interest rates have the same result.

A discriminatory policy towards agriculture in foreign trade and the economic and social instability of the country tend to diminish drastically private benefits of long-term investment projects. The use of new production systems is thus made uneconomic and risky. These facts focus attention on one point: the work of research and extension is the key to the problem. The other conditions depend on economic policy which can either encourage or retard the modernization of agriculture.

Evidently a production system can never be reduced to a single "practice". But this does not prevent research from making recommendations of isolated practices. In this case it must be stated in which production systems these practices fit. Failure to do so has already resulted in considerable damage being done to the farmers.

It must be remembered that science recommends practices which cause an upset in the existing equilibrium which has existed for a long time. Modifying a part of the production system adopted by the farmers, while leaving the other as it was, almost always results in upsetting the equilibrium on the wrong side, from the economic point of view, since profit is decreased instead of increased. Improving the health and nutrition of a herd of low productivity may give a result not corresponding to the cost. Technologies which require high investment with a return only over the medium term, increase the probability of failure of the farmer unless an adequate financing system exists. Because of this, farmers resist the adoption of these technologies. Nowadays, it is common to see the adoption of these technologies, but with the government paying the greater part of the bill.

FACTORS AFFECTING DISSEMINATION OF NEW TECHNOLOGY

Dissemination of technology depends on various factors, some of which are mentioned below:

1. The existence of a substantial number of alternative production systems to those in use by the farmers, that are more efficient from the economic point of view. In many agricultural operations the biggest limiting factor is the small number of alternatives and which, above all, require heavy investments and expose the farmers to big risks. They are not accessible to small farmers and, in many cases, the large landholder only puts them into practice after receiving heavy subsidies;

2. The economic policy to the extent that it raises the price of inputs, reduces the prices of products and increases price fluctuation, makes inviable technologies which require larger investments and which offer greater risks in the implantation phase. In a very uncertain situation, the farmer prefers the technology which requires a minimum expenditure of money. He even attempts to divide the risk with the hired labor through a sharing arrangement, etc. Since modern technology involves the purchase of costly modern inputs, it is rejected in this circumstance;

3. Production systems which require close and costly supervision and with which great risks of loss are associated if the recommendations are not strictly followed, are also not likely to be adopted by farmers;

4. The farmer certainly needs to be informed about new technology. This requires that the extension workers know thoroughly what they hope to teach. The biggest problem facing Extension and Technical Assistance is to prepare its workers who are almost always very young. The production systems elaborated also need to facilitate the training job; the problem of diffusion of technology is today much more related to the technical knowledge of the extension workers than to their ability to communicate.

5. There are also factors which involve the education of the farmer, land ownership, rent laws, etc., which in some cases sharply retard the diffusion of technology. The rural credit system does not always favor long-term investments and discriminates against small and medium farmers. The lack of companies which acquire expensive machinery and rent it to farmers tends to make inviable technologies which depend on this machinery.

6. Rural Extension always faced the problem of reaching the mass of farmers. From this point of view, the conclusion is obvious: there are a lot of farmers and few extension workers. But there are also other factors: the geographical dispersal of properties; the poor quality of country roads; the low educational level of the small and medium farmers who require a direct contact with the technician either through individual or group meetings.

Within the perspective of increasing production surplus, the problem would be greatly simplified since a small percentage of farmers hold the greatest portion of agricultural land. It is therefore necessary to reach this small fraction of farmers. This can be done with help from private technical assistance firms, while drastically reducing government investments.

The implication in a decision of this kind is that the small and medium farmers would be left marginalized from modernization. Such a decision would help aggravate the internal market supply problems both in regard to the food basket of the poor consumer and in income distribution in rural areas. It would certainly increase the rural-urban migratory flux.

There is no way to avoid working with small farmers who have, in fact, shown a high response capacity in terms of production increases both in Brazil and in other countries.

The big question is how to serve them. There are millions of them spread throughout the national territory. After Huffman's study (1974), it became evident that instruction is a substitute for extension work. In the case of small farmers, this substitution does not work very well since the majority of them do not have access to a primary school which is often lacking in rural areas.

Rural Extension will have to increase its staff in order to improve service to the small farmers. As already mentioned, a possible alternative would be to give public extension the responsibility for this type of work while large farmers would be taken care of by private assistance.

Even so, government investments will still have to grow very sharply if outlook and work methods are not changed.

The primary school program will have to be revised to include courses on agricultural practices. The Extension Service could collaborate in this task.

Extension work with groups rather than with individual farmers, a methodology already known to Brazilian extension workers, will have to be revised and considerably increased.

There is a need to prepare special publications that can be read by people with a minimum amount of education. The same approach should be followed by radio and television which today constitute a powerful means of communication in farm communities.

FINAL OBSERVATIONS

Applied agricultural research may be understood as a search for new technologies within the boundaries of existing scientific knowledge. The role of research is to increase the number of alternative production systems. This will give the farmers more opportunities and permit each one of them to make the best choice, considering the existing markets, the characteristics of their assets, knowledge, personality, and other factors.

EMBRAPA considers the development of knowledge a continuum which starts with a research project seeking an answer to an agricultural problem, which has originated with a farmer and which ends with the farmer, when he puts into practice the results of that research in order to increase his productivity and his income. The broad objective is to benefit mankind by the advancement and utilization of agricultural and related sciences through technological innovation, and creation of new technology for agricultural producers. The participation of extension and technical assistance in all stages of this process is of major importance.

Research results must be disseminated and adopted by farmers to affect agricultural productivity. Extension activity helps speed up the adoption process and increase the percentage of adoption. Thus, the effect of a given technology on agricultural productivity depends on the level of extension activity. On the other hand, the effectiveness of extension depends upon the effectivess of research. Without research, no new knowledge can be extended by extension agents. Therefore, research and extension are interrelated and complementary.

Agricultural policy will be dominated by the concern with increasing the agricultural surplus for supplying internal needs and for export. Its principal support will be an increase in the productivity of land and labor and a stabilization of production. Policies designed to expand the agriculture frontier will lose their

importance. As a result, the institutions which develop knowledge — research and rural extension — must be strongly supported. The product of their work is the necessary condition for the self-sustained growth of agricultural productivity.

Education makes the acquisition of skills easier but an expansion of educated manpower is not equivalent to an expansion of skilled manpower. Since modern technology is human capital intensive, pressure on the government will grow to expand rural manpower training programs which will be an important area of action for rural public and private extension.

In general, the public research and extension efforts are done as "service" while the private sector undertakes these activities for "profit". As a result, the role of public research and extension initiative theoretically should concentrate on matters closely linked with the public well-being, emphasizing social benefits. As a result, the role of private technical assistance will grow while public extension will reduce its function in relation to the large producer, and further turn to small ones.

The spread of new technology function, contrary to what is generally believed, is much more active in a modernized agriculture. What does vary is the participation of private enterprise because the degree of education of the farmers gives them a greater capacity to decodify the messages which the communications media, such as journals, television, technical reviews, etc.

Economic policy, the existence of research results which are profitable for the farmers, and technical knowledge of extension workers, today have a much greater influence on the velocity of dissemination of new ideas than the capacity for communication in the strict sense of the work. Training of its technicians stands out as one of the major problems faced by rural extension today, even more so in view of the extraordinary advance of the agrarian sciences.

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