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BRAZILIAN TECHNOLOGIES IN AGRICULTURAL AND AGRO-INDUSTRIAL DEVELOPMENT

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BRAZILIAN TECHNOLOGIES IN AGRICULTURAL AND AGRO-INDUSTRIAL DEVELOPMENT

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Technology can be defined as the systematic application of scientific knowledge to productive activities. It is knowledge applied to the world of objects, changing the relationship between subject and object, in the direction desired by the first. Thus, the history of technological development can be described as the trajectory of Man's domination of Nature. And it is in this context that one must situate agricultural research, an undertaking that is frequently responsible for profound transformations, both at the level of the productive unit and in relations with the economy as a whole.

The generation of agricultural technology depends on three fundamental factors: a political decision, the availability of suitable equipment and facilities (physical capital) and highly trained human resources (human capital). In Brazil, the political decision was taken with the creation and physical-institutional development of a Cooperative System of Research which has, with the passing of years, taken on concrete form with support provided by the Government to its projects.

Brazil invested voluminous resources in the founding and construction of research units located in strategically located production and consumption regions and gave these units tasks of regional or national scope. The country instituted a program aimed at the formal and continuous training of researchers who studied agricultural research at the best institutes and universities, both in Brazil and abroad. As a result, of the 1,600 researchers now working for just one of the companies that participate in the aforementioned Cooperative System – Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA (Brazilian Agricultural Research Company) – more than 75% have complete masters and/or doctoral courses.

The results of the research and experiments carried forward by EMBRAPA have gained a position of international renown for the company. Its work in the tropical, semi-arid and savannah regions is unique in the world. Under these conditions, it has developed technologies and services that can be utilized in other countries, particularly those of the developing world with edaphoclimatic characteristics similar to those of Brazil. In this way, it has prepared a very encouraging foundation for cooperation with these countries, through the marketing of technologies and services in the area of agricultural research.

Brazilian exports of agricultural technologies and the adoption of these technologies by countries at an equal stage of development are undertakings that are advantageous for both of the parties involved.

The agricultural technologies that have been generated by the Cooperative System of Agricultural Research, under the management of EMBRAPA, can be classified as follows:

1 Resources Research

Here, the technologies and services related to the use of soils, genetic resources, pesticides, improved seeds and bioenergy are included.

1.1 Soils

Soil research and related studies are important in the sense that they provide us with an overall picture of the nature, distribution and quantification of this natural resource. Integrated knowledge of the morphological, chemical, physical, minerological, micromorphological and microbiological characteristics of the soil provides one with a better understanding of the agricultural processes – such as soil and water management – involving fertilization, irrigation and drainage. At the same time, the analysis and extended application of these results to similar agroclimatic areas, for both agricultural and non-agricultural purposes, is also made feasible.

Today, the Cooperative System of Research is prepared to render consulting services in the areas of soil surveys, the study of the agricultural aptitude of land and the assembly of laboratories designed for the characterization of soils and fertility.

1.2 Genetic Resources

In the area of genetic resources, an efficient system of introduction and conservation was implemented and has contributed greatly to the gains that have been obtained in terms of Brazilian agricultural productivity. Laboratories are already available that have been designed with the aim of efficiently controlling the phytosanitary state of the matter introduced and treating the same matter when contaminated.

The Active Germplasm Banks now include cultivars, lineages, clones and like wild species. These facilities are responsible not only for conservation, but also for characterization and evaluation. The data produced through these activities are of essential importance to the utilization of the conserved materials, to the multiplication demanded for storage and, finally, to exchanges of information in Brazil and with the foreign community.

The introduction and conservation of genetic resources would be of little value if users were not provided with information on the availability of the germplasm and its essential characteristics. With this in mind, computerized programs have been prepared that provide immediate information on the material sought by the researcher.

The Cooperative System of Research also concerns itself with the conservation of animal germplasm. Using rapid freezing techniques, semen, gametes and embryos are being conserved and now represent an alternative auxiliary method through which it will be possible to form a gene bank capable of meeting future needs.

1.3 Basic Seeds

Improved seed production in Brazil went through a period of very sharp growth in the 1970s. Since then, the private sector – working through more than two thousand producers and their cooperatives – has taken on the task of producing and marketing the major share of the improved seeds utilized in the country.

The availability of high quality seeds depends on a series of activities including the creation of new cultivars through the introduction of genetic improvements, the formation of stocks of basic seeds and production of commercial seeds, before these seeds can be marketed to individual farmers.

In this case, EMBRAPA acts as a link between research and the producers of improved seeds. The success that has been attained in this area has transformed the company into a potential exporter of experience in the development and evaluation of seed production projects, the elaboration of seed production programs, the planning, assembly and operation of processing units, and the production and marketing of high quality basic seeds.

1.4 Energy

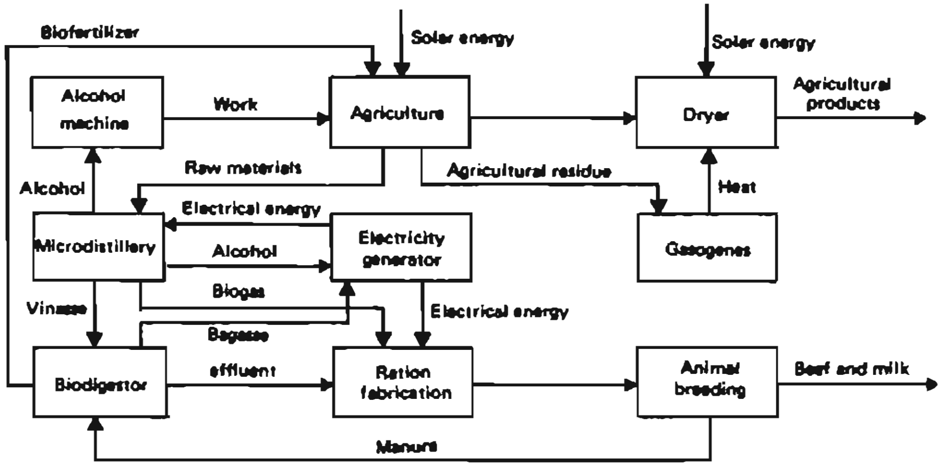
The impact of the world energy crisis was felt most strongly by those nations that are heavily dependent on imported energy. The efforts made to overcome these difficulties concentrated on the goals of increasing the production and reserves of national petroleum, maximum growth in the production and utilization of local and renewable sources of energy, the substitution of petroleum derivatives and energy conservation.

On the basis of this guideline, research was initiated in the pursuit of alternative sources of energy capable of substituting a part of petroleum-derived fuels, and the development of more rational energy utilization systems.

At the present time, agricultural research has already obtained highly promising results in the production and utilization of alcohol, biogas, gasogenes and solar energy.

Among the technologies that have been developed for the purpose of economizing the use of imported energy in the agricultural sector, one should cite the use of agricultural residues as a substitute and complement to chemical fertilization, the biological control of pests and disease and technologies that utilize animal traction. The integration of research in this area has made it possible to develop systems capable of making the rural establishment self-sufficient in terms of energy.

This is a pioneering system based on an integrated and harmoniously interconnected complex composed of a microdistillery, biodigestor and electricity facilities. The very peculiarities of the system have contributed decisively to minimizing the potentially damaging effects that distillery subproducts can have on the environment. The general idea can be summarized as the use of solar energy in the form of biomass and its transformation into the inputs (fuels and fertilizers) that are used in the different stages of agricultural production. Part of the biomass is transformed into alcohol at the microdistillery.



In the projects now being carried out, the combination sorghum-cane has received special attention, since efforts have sought to demonstrate the feasibility of these products as a system of cultivation and as an industrial raw material. The fact that these crops are complementary reduces the period during which equipment remains idle, coupled with the speed of multiplication of saccharine sorghum which is at least 25 times greater than that of cane.

Saccharine sorghum grain used as animal feed finances part of the production costs of the integrated bioenergy system.

The culms are used as the raw material for the production of alcohol, while the vegetable residues are fed into the biodigestor. The agricultural production system is powered through the application of the biofertilizer – the fermented residue of the biodigestor – while the alcohol produced is used as a fuel in tractors and other machines. Mention should be made of the fact that the vinasse and part of the bagasse are used in the process of biodigestion, thus making a substantial contribution to the reduction of environmental pollution.

Closing the cycle, the electricity generator complex can be activated by the biogas or alcohol. Consequently, the electrical energy needs of the microdistillery are supplied by the latter component. Furthermore, part of the gas can be used for other purposes on the farm, such as the drying of grain and domestic consumption.

The work that has been carried out in Brazil in the field of bioenergy research is not only pioneering but also manifestly successful. In the coming years, it is expected that demand for bioenergy technology in countries with problems similar to those of Brazil will increase considerably.

In tropical countries like Brazil, it is also important that one have sufficient knowledge regarding the utilization and production of those chemical products that are needed to ensure adequate maintenance of phytosanitary conditions of the crops. In this area, the country is in a position to provide consulting services in the use of pesticides, including the aspects of biological evaluation, formulations, application techniques and environmental impact evaluations.

2 Product Research

Taking into consideration the varied edaphoclimatic conditions of the country – many of which are quite similar to other regions such as Egypt, Argel and Tunis, this heading would cover the technologies and services related to pratically all of the major food crops.

In the light of the necessity of satisfying the regional peculiarities of Brazil, specific strategies were adopted in order to enhance our experience in the generation of technologies suited to the varied edaphoclimatic conditions of the country, and particularly the regions of the savannahs, semi-arid tropics and humid tropics.

2.1 Vegetable Production

In the case of agricultural products, Brazilian research has sought with increasing intensity to create new, more productive, more resistant and improved varieties and lineages, that would be capable of maximizing the responses obtained as a result of the application of modern inputs.

Among the examples of advanced research now being carried out by the Agricultural Research System, under the management of EMBRAPA, mention should be made of new varieties of wheat, rice, soybeans, beans, sorghum, fruits trees, vegetables and pastures, the development of in-depth studies aimed at improving the management and practises involved in the cultivation of alternative crops, the creation of many cultivars adapted to the different regions of the country – many of which are similar to other Latin American countries, pest and disease control, improved biological control of pests and diseases, chemical and biological fertilization, with excellent results in terms of soil biology.

In recent years, research in the area of pest control has sought to make greater use of alternative techniques that can lead to considerable reductions in the use of chemical insecticides. Aside from curtailing production costs, this research seeks to reduce the risks of human and animal intoxication and environmental pollution caused by most of the chemical insecticides now available, to insignificant levels. Consequently, biological control will play a role of fundamental importance in the pursuit of these objectives.

In the case of the soybean caterpillar, for example, it has been demonstrated that spraying of the crops with a polyhedrosis virus can be just as efficient as chemical control. In the case of the pests that attack the cotton crop, techniques recommended by research have made it possible to reduce the costs of these operations by 50%, in relation to the methods traditionally used by farmers.

The biological control of the wheat louse has also resulted in sharp cuts in costs, through savings on both insecticides and the operations involved in their application.

All of these techniques are simple and are easily adapted and assimilated by farmers. At the same time, the large scale use of these technologies by farmers can have highly beneficial effects on the environment and the quality of life of the population.

2.2 Animal Production

In the area of livestock production, the technologies of greatest importance are those related to the formation of pastures, nutrition, feed, genetic improvements, health, handling, reproduction and animal improvements.

In the segment of poultry, the National System of Research is now in a position to transfer technology to other countries, in the following areas:

– Nutrition

- Digestibility, metabolism and availability of amino acids;

- Protein, amino acid and energy nutritional needs; and

- Formulation of low cost feed.

– Genetic Improvements

- Methodologies for evaluation and selection of lineages of poultry for slaughter.

– Health

- Standardization and control of biological reagents for the diagnosis of poultry diseases (antigens): Newcastle disease, avian infectious bronchitis, Gumboro disease;

- Techniques for the diagnosis of avian diseases;

- Control and evaluation of the efficiency of the biological products used in poultry farming (vaccines);

- Field and laboratory evaluation of the different types of vaccines (inactivated; attenuated strains) for the control of Gumboro disease.

Another area in which international advisory services could be provided is in poultry farming.

In the case of beef cattle, feed based on mineral mixtures has been tested and has been shown to be a good economic response as a dietary supplement for yearlings. Research has also concerned itself with creating races that are adapted to varying climatic conditions. This has been done by taking advantage of the resistance of Zebu cattle (principally, Nelore) and the quality and productivity of European races (Aberdeen, Angus and Charolês, among others, coupled with studies in the areas of forage, pastures, animal nutrition, genetic improvements and handling, animal health and production economy.

The technologies and services that could be covered by agreements with other Latin American countries are as follows:

- Forage and pastures, animal nutrition, animal reproduction, animal improvement, animal health, economy and systems;

- Production of inoculants for tropical leguminous products;

- Techniques of genetic improvement of forage crops;

- Formulation of mineral mixtures;

- Formulation of beef cattle rations;

- Implementation of programs of artificial insemination; and

- Estimates of genetic parameters, among others.

II - Technological Development in the Agro-Industrial Sector

The Cooperative System of Research has a wide array of services and technologies applicable to the sector of food processing.

Among the examples that could be cited are technologies to be used in obtaining natural additives for foodstuffs, knowledge of the processes involved in quality control and the adaptation of farm products to the demands of agro-industry and consumer markets.

1 Citrus Fruits

In terms of the world import market, the citrus fruit agro-industry is taking on a position of increasing importance, in the light of almost total past dependence on the American industrial structure, now the world's largest exporter of citrus juices and concentrates.

In recent years (1962 to 1982), highly favorable international market conditions for citrus concentrates, the availability of raw materials and the technological development of the sector, coupled with the commercial success of Brazilian production units, particularly in the State of São Paulo, have raised this country to the rank of second largest international exporter of these products, particularly, frozen concentrated orange juice.

Among the citrus products exported, frozen concentrated orange juice is certainly the most important, when compared to citrus meal, lemon, grapefruit or pomelo, and. tangerine juice and other subproducts. During the period extending from 1962 to 1982, exports with 65^{0} Brix expanded from 0.2 to 521 thousand tons.

Growth in exports of concentrated juices took place over a very short span of time (1962 to 1968), when Brazil moved into second position among the world's producers of industrialized orange juice (after the United States of America) and the principal exporter of frozen concentrated orange juice.

Today, agro-industrial technologies in the sector of citrus fruits that could be transferred on the basis of commercial agreements with other countries, institutions and interested companies include the following major fields:

- Frozen concentrated juice;
- Simple juice;
- Frozen concentrated pulp wash juice;
- Essential oils;
- Citrus pulp meal; and
- Limonene.

Working through various research institutions and consulting firms, Brazil has developed full technological capacity in the sector of citrus products and is in a position to provide advisory services in the elaboration of projects, involving the implementation of citrus product processing units.

Aside from this, these institutions are able to supply technical assistance in the implementation and operation of industrial units, while training specialized personnel in the phases of processing and quality control.

In terms of equipment specifically designed for use in the citrus product industry, one can affirm that Brazil is now prepared to produce 90% of the equipment demanded for the industrialization process.

There are a number of different species and cultivars of tropical and temperate climate fruits with many analogous biological characteristics, and this fact has greatly facilitated the elaboration of solutions to problems of a phytosanitary nature.

Thus, all of these species have the same dormancy season, the period during which farmers subject the crops to winter treatment as a means of controlling pests and disease.

When spring blooming (natural and induced) takes place, attention is given to the period of sharp vegetative growth without the interference of negative factors (diseases and pests). This is maintained through the application of a strict system of phytosanitary treatment that, in some cases, continues right up to the end of the cycle, when the fruit is harvested.

Research and extension services have taken special care to avoid the indiscrimate introduction of vegetable materials. This is done by strictly controlling the standardization of seedlings and closely inspecting nurseries insofar as the propriety and health conditions of the materials utilized are concerned.

One can certainly affirm that Brazilian research and extension organizations now possess the conditions that make it possible for them to provide the necessary guidance to producers who intend to implement high technology orchards, based on what is most modern in the sector and on a par with the techniques found in any other part of the world.

In the last decade, production of tropical fruits in Brazil has expanded sharply.

Between 1973 and 1983, the fruit that registered the most rapid growth was the pineapple, as output rose from 323 million units to 445 million, in the aforementioned period.

An analogous situation is found in the case of bananas, as Brazil has moved into a position of great importance on the world producer market.

In the case of passionfruit, production is almost totally concentrated in the north and semi-arid region of Brazil, where approximately 80% of output is channelled to processing units which transform the product into juice. The remaining 20% are marketed as fresh fruits of for the preparation of homemade juice and sweets.

Other tropical fruits such as the papaya and mango have also been expanding rapidly and, due to increasing demand for these products on both the domestic and foreign markets, production has already reached a reasonably significant scale. In the case of guava, production is almost totally consumed in the manufacture of thick pasty sweets, while a small share is sold in the fresh fruit market both domestically and internationally, though the variety of the fruit used in the latter case is not the same as that utilized in the making of sweets.

The Brazilian tropical fruit processing industry is scattered about all parts of the country and distributed among small, medium and large scale industries.

Most of these are small companies that concentrate on the making of sweets – normally termed homemade – utilizing simple technologies with a low level of technical content.

Normally, the medium size companies produce fruit preserves, purée, jellies, sweets and pasteurized fruit juices.

The large companies concentrate their efforts on the production of concentrated juices, taking advantage of the out-of-season period of citrus fruits to process pineapple, passionfruit and others.

Mention should be made of the fact that 70% of the companies that industrialize tropical fruits are located in the South and Southeast of Brazil.

In 1982, Brazilian exports of fruits and derivatives totalled US$ 751 million, and were concentrated on oranges, Brazil nuts, bananas, cashew, figs, melons and papaya. Among preserves, the most important were those made of pineapple, bananas, papaya, mango and peaches. The leading juices were those of citrus fruits, passionfruit, pineapple and grapes.

Acting through research institutions involved in the study of tropical fruits, Brazil has reached a level of technical capacity that has placed the country in a position of being able to provide advisory services in the elaboration of projects involving the implementation of tropical fruit processing units (Table 1).

The aforementioned institutions can supply technical assistance in the implementation and operation of industrial units, the training of personnel specialized in the different phases of processes and quality control.

In terms of the equipment specifically designed for the tropical fruit industry, one can state with certainty that Brazil is able to produce more than 95% of the equipment used in the industrialization process.

TABLE 1. Tropical fruits and the major technologies available.

Fruits	Products							
	Juices[1]	Sweets in syrup (preserves)	Fruit jellies	Thick sweets	Dried fruits or dissec*	Fruit pulp	Purée **	Nectar
Pineapple	X	X	X					
Bananas				X	X		X	
Cashew	X			X				X
Guava		X	X	X				X
Papaya						X		X
Mango		X						X
Passionfruit	X							

* Flakes and/or banana sweets
** Aseptic and/or acidified purée
[1] Juices - chlorified
- simple juice
- frozen concentrated

3. Soybeans — Oil and Meal

Since the 1970s, soybean cultivation in Brazil has been expanding rapidly, rising from 4.0% of the world total in 1969 to 21% in 1976.

In the area of production growth, Brazil has registered one of the sharpest rates in the world. Among the many factors that have contributed to this phenomenon, mention should be made of the following: good world prices, producing substantial gains for farmers; high level of technology applied to cultivation; utilization of the cooperative system; significant growth in the nation's industrialization capacity in the area of oils, together with a rapid rise in crop yields, now at practically the same level as in the United States.

The vegetable oil industry in Brazil has a nominal installed capacity of 89,989 tons/day, or 26,997 thousand tons/year, based on 300 days of operation per year.

In terms of the processing technology now utilized, 88% of nominal capacity involves the process of continuous solvents, 11% is done through the use of discontinuous solvents and 1% by mechanical pressing.

An analysis of the processing industry shows that 70% of the crushing units work exclusively with soybeans; 15% operate with other oil-bearing grains, aside from soybeans and 15% process cotton seeds, peanuts, castor beans, sunflower seeds, corn, linseed, rapeseeds, rice and tung seeds.

In the period extending from 1977 to 1982, Brazilian exports of unrefined oil remained constant, while foreign sales of meal and cake and refined oil expanded by about 49% and 1,266%, respectively.

In terms of the industrialization process, Brazil has acted through a number of consulting institutions and is now capable of elaborating projects for the implementation of processing industries.

These institutions are able to supply technical assistance in the implementation and initial operation of these industrial units, while training personnel specialized in the different processing stages and quality control.

In terms of the equipment specifically designed for the industrialization of soybeans, the country is prepared to produce 100% of the equipment and machines needed by this industrial sector.

Brazilian technologies that could be the subject of commercial agreements with other countries cover the following areas:

- unprocessed soybean oil;

- refined edible soybean oil; and

- soymeal, principally.

4 Grains

Among all of the foodstuff industries, the grain processing sector in Brazil is one of the most highly developed and solid industrial structures. This is due to the fact that the consumption of grains and derived products is traditional in Brazil and extremely common in all parts of the country.

Brazil has vast experience in the industrialization of grains and has invested heavily in research, with the aim of developing and perfecting its technology.

Grain production in Brazil now totals almost 34 million tons, while the harvested area covers about 22 million hectares. Corn accounts for the greatest share of this production, with about 22 million tons, followed by rice, with 9 million tons, in approximate terms. The third most important type produced in

Brazil is wheat, with output of about 2 million tons. Oates, barley, rye and sorghum are produced on a lesser scale, with production of about 0.5 million tons for each of them.

At the present time, grain consumption in Brazil totals about 35 million tons. Consumption has increased with the passing of time, though not with a great deal of regularity. The most commonly consumed grains are corn, wheat and rice, while oates, barley, rye and sorghum are consumed on a lesser scale. The country consumes about 23 million tons of corn, of which approximately 2 million tons are imported. Wheat consumption comes to about 6.5 million tons, of which approximately 4 million tons are imported. Rice consumption is in the range of 6 million tons, making it possible to export about 3 million tons of the product.

The industrial structure involved in the processing of grains is as follows:

— Milling Industry

· Wheat milling

In Brazil, this industry has about 187 units that mill approximately 6 million tons of wheat per year.

· Corn milling

371 facilities, with output of about 20 million tons per year.

· Rice processing

1424 units, processing 9 million tons of rice per year.

· Baking industry

13 thousand establishments that produce bread, of which 24 are large scale industries.

— Biscuit Industry

· 6 thousand production units, of which 63 are large scale industries.

· Macaroni industry

365 establishments that produce macaroni, of which 81 are large scale industries.

- Beer industries

  16 beer production industries.

- Cassava starch and flour industries

  5 starch industries and 9 that produce cassava flour.

- Extrusion of grains and production of instant foods

  15 industries involved in this type of production.

- Production of corn-based glucose and fructose

  2 industries producing corn-based glucose and fructose.

At the present time, technology in this sector is available in the following areas:

- Grain mills

  Brazil has the know how to build wheat, corn and sorghum mills with capacities ranging from 24 to 1000 tons per day. Three companies produce a complete range of equipment for these mills, while others produce incomplete product lines.

- Baking, pastas and biscuits

  Brazil has wide-ranging experience in the making of bread, biscuits and macaroni. There are now 40 industries that produce equipment for the biscuit sector.

- Extrusion and gelatinization of flours

  The nation's extrusion technology is low cost, modern and highly flexible. In this area, Brazil possesses technology for the production of the following: snacks and cereals (breakfast), baby food, instant food pastes not based on wheat (cassava, potatoes, etc.), pre-gelatinized flours for industrial use (textile, paper industries, oil drilling and construction of foundations). Aside from this, Brazil has also mastered the technology involved in the utilization of turbo-gelatinizers in the stewing of flour for human and animal consumption, as well as wide experience in the production of tunnel-type driers and even turbodriers. Two industries now produce equipment for the gelatinization of flours, while one produces extrusion equipment.

- Starch extraction and modification

  Brazil now has a number of starch producing industries, located in all parts of the country. Starch is normally produced on the basis of cassava and corn.

  Brazil has developed technologies in the area of modified starches for varying applications in the food industry: thickeners, starches resistant to alkaline or acid treatments, ionic starches; and applications in other industries, such as: oil well drilling, foundations, industrialization of paper, textiles. Three industries now manufacture equipment for the extraction of starch while a large number of manufacturers turn out the equipment and chemical products needed to obtain modified starches.

The Cooperative Research System is now fully able to establish technical cooperation agreements involving agro-industrial technology transfers in the sector of grains. This can be done through universities, research institutes and such applied research institutions as the Food and Technology Center, which is subordinated to EMBRAPA. This unit has developed research in the areas of wheat, corn, sorghum, rice and cassava, particularly in the following areas:

- milling;

- flour processing;

- thermoplastic extrusion of flours for the production of pre-gelatinized, instant, foods snack type food, baby food, texturized vegetable proteins and pre-gelatinized flours for industrial use (paper and textile industries, oil well drilling and foundations), among others.

5 Dairy Products

EMBRAPA has developed a wide array of research programs in the area of dairy goods production, including:

- Technology in the making of fine cheeses such as Gorgonzola, curd cheese, Grana, Petit-Suisses, Saint-Paulin, all of which are made with cow milk;

- Technology in the making of cheeses using goat's milk, such as Chabichou and Crottin, Saint Mause and Bursin.

- Milk-based deserts using non-fat milk with tropical fruit flavors;

- Utilization of non-fat milk for the making of curd cheese and Petit-Suisse, buttermilk and flans with special flavors and aromas.

Aside from what has been said above, studies are being carried out for the purpose of obtaining a milk-based beverage for the low income population, schools, hospitals and old age homes.

This drink – projected as a dietary supplement for children and the low income population – was developed on the basis of cheese whey, and possesses very high nutritional value since it is composed of carbohydrates, proteins and vitamins. In the making of this drink, the following products are used: cheese whey, pasteurized milk and fats, sucrose and a stabilizer. Chocolate (cocoa powder), vanilla and strawberry aromas were preferred by consumers. The product has the following composition: total solids = 13.12%; fats = 1%; total proteins = 2.01%; sugars = 9.65%. Energy value is approximately 60 kcal/100 ml, while public acceptance is 9 on a 1 to 9 hedonic scale, representing a very high level of consumer acceptance. The useful life of the product at $5 \pm 1^{O}C$ is about 4 days and the product is packed in polyethylene. An analysis of the composition of this drink shows that its calorie-energy content is satisfactory to meet the needs of the human organism, particularly in the case of adolescents, pregnant women and those suckling children.

Research is also being carried forward with the aim of improving and diversifying the industrialization of buffalo milk, which is known for its high protein value and fat content.

In the area of cheeses, highly promising results have been achieved, particularly with regard to Soft White, Mozzarela and Provolone, which have produced average yields of 4.56, 5.50 and 7.43 liters of buffalo milk for each kilogram of final cheese. These figures clearly evince the great potential of this type of milk, particularly when compared to the average productivity of cow milk, which demands 8 to 10 liters of milk for the same quantity of cheese.

6 Natural Dyes

In the marketing of industrialized foodstuffs, color is a factor of great importance. However, during the process of industrialization, very significant color changes normally occur, thus creating a need for dyes that are capable of restoring the color composition of the original product. Traditionally, the food industry has utilized synthetic dyes in this process. However, evidence accumulated over the past 15 years has shown that many of these synthetic dyes are dangerous to human health and can be held accountable for the increase in thyroid diseases, liver problems and even cancer. Consequently, use of these products is being restricted.

EMBRAPA has been seeking to identify low cost raw materials with a high dye content that, through the process of extraction and purification, will make it possible to produce non-toxic dyes with stable colors that would be well suited to the food industry. As a result of all this, dye production technologies have been developed using such raw materials as the fruit of the annatto tree, residues of grape, beet and sweet potato industrialization.

The dye principle of the fruit of the annatto tree is a carotenoid, the bixing with coloring ranging from yellow to orange, depending on the concentration and is used principally in dairy products, rations for birds, in salmon, in meat products and in the standardization of the coloring of orange peels.

Beets are a low cost raw material that can be easily cultivated and possesses a relatively high dye content, known as betalaines, in two basic groupings: those that are red in color and are called betacianines, with a content that varies from 75% to 95% of the total coloring of beets, and those with a yellow coloring, called betaxantines. The use of betalaines, considered to be excellent dyes for use in dairy products (ice-creams, aromatic milk products, yogurts), bakery products, jellies, soups, meats and like products, is permitted by international legislation, with no restrictions on quantity. They can be marketed in concentrated liquid form or in powder.

Antocianines are important elements found in red wine and are responsible for the red coloring of grape juices and wines. The ideal raw materials for obtaining this product are the skins and seeds of grapes, both of which are subproducts of the wine industry and, naturally, are abundant and low cost. Aside from the fact that these are widely used in the coloring of yogurts, ice-creams, fruit preserves, jellies and candy, the product is also very useful in the standardization of the color of concentrated grape juices.

Antocianines are also present in sweet potatoes. In this case, the technology of extracting the dye is based on the solubility of the starches which, in turn, is done through acid hydrolisis or the use of enzymes. This process produces pigment concentrates that are rich in dextrose, maltose and maltodextrines. This process is original both from the point of view of the raw material utilized and from that of the technology used to obtain the dye.

The dye obtained from sweet potatoes is used as a substitute for the synthetic dye FDC Red no. 2, the use of which is prohibited in foodstuffs by national and international legislation.

III - Technological Development in Complementary Agricultural Sectors

1 Irrigation

In order to ensure the success of an agricultural undertaking, there must be a guarantied and sufficient supply of water.

Natural rainfall does not always coincide with the hydric necessities of plants, in terms of volume. During the period during which grain is blooming on the stalks – precisely the period during which water demand is greatest – the natural supply of water may often be insufficient, demanding that measures be taken to supply water artificially.

The use of irrigation is a guaranty of good harvests independently of the occurrence of natural rain, making it possible to obtain as many as 5 harvests in just two agricultural years. Productivity often doubles, while production may even triple.

The Cooperative System of Agricultural Research has developed a wide array of studies with respect to all of the known forms of irrigation – flooding, infiltration, corrugation, sprinkling and dripping. These studies have all had the same objective; increased productivity in order to achieve a rapid return on capital investments.

The efficiency of the irrigation systems produced in Brazil has already been widely demonstrated. These systems are classified as follows: conventional, direct mounting, self-propelled, central pivot, irrigation through dripping and windowed tubes, principally.

1.1 Conventional

These are irrigation systems composed of a suction and settling line, pump and secondary lines with sprinklers. The basic characteristic of this system is the movement of the secondary lines, sprinklers, principal line, pump and suction line which, with adequate planning, can be utilized in just about any agricultural situation. Frequently, these systems are used in small areas and for varying crops, particularly vegetables and legumes. If sufficient manpower is available, these systems can also be used in larger areas in fixed or movable installations.

1.2 Direct Mounting

This is a compact sprinkling system mounted on a tubular chassis and 4 tires, diesel engine, centrifugal pump, suction unit, primer valve and sectoral water cannon.

It is projected to opérate alongside a water channel distributing the water through sprinkling for irrigation or for the effluents of industries and distilleries (vinasse). The system is protected by a hood and air filter in an oil bath and is transferred from one place to another through the use of a small agricultural tractor.

1.3 Self-Propelled

This is a chassis with four tires, a single sprinkler, hydraulic turbine propulsion system, drum and steel cable and flexible hose.

It is recommended for areas of more than 12 ha, where manpower is in short supply. It can be used for crops that range from medium to large in terms of size.

1.4 Central Pivot

The central pivot system is composed of a distribution line, water main, piping, suction system, pump and settling line, all connected to the central pivot. The distribution line is made of zinc-coated steel and is equipped with sprinklers. The distance between the sprinklers and the land can be regulated, since the entire system is mounted on towers that are equipped with tractor type tires.

These towers have an electric propulsion system (motor driven system that transmits movement through the drive shaft, to continuous thread reducers), making it possible for the system to operate in complete circles. This system is recommended for areas of 18 to 120 hectares.

1.5 Irrigation by Dripping

Irrigation through dripping demands a sophisticated system of water filters and application of fertilizers and other chemical products. This system was projected specifically for highly intensive farm use. One of the technical and agronomic objectives of this irrigation method is the possibility of obtaining either high levels of humidity or low levels of soil retention capacity, without causing aeration problems.

The characteristics of this irrigation method are as follows:

- minimum variations in the soil humidity content during the irrigation cycle;
- water supply only to determined parts of the soil;
- greater efficiency in the radial system in terms of the absorption of water;
- reduction of the problem of salinity in the plants caused by the transfer of salts to areas beyond the volume occupied by the radial system, and by the reduction of salt concentrates, since the humidity of the soil is maintained at high levels;
- the most efficient part of the radius is directly supplied with nutrients;
- savings on water due to a reduction of evaporation, surface runoff and deep percolation.

Aside from this, the operational pressure of the system should be quite low since the orifices have very small diameters. The system operates 24 hours per day with a minimum of manpower. Technological progress has made it possible to produce equipment that can be adapted to just about any situation and to highly varied types of crops, ranging from large trees, planted in lines or in other formations, to vegetable species.

1.6 Windowed Tube

The method of irrigation through the use of furrows is particularly suited to crops that are planted in rows and, due to its low implementation cost, is recommended for small and medium properties.

Normally, the use of irrigation through furrows demands the construction of contour furrows, following an incline that is recommended on the basis of technical studies. The distribution canals are normally built in the direction of the steepest incline, demanding the use of special structures that will slow the flow of water and thus avoid erosion. In this case, the windowed tube can substitute the irrigation canals since this not only avoids contact between the water and soil in the direction of the sharpest incline, but also makes it possible to regulate discharge in keeping with the size of the irrigation furrows and to control the process of erosion.

Utilizing a line of 50 meter windowed tubes moved four times a day, with an irrigation frequency of five days (once a week), one çan irrigate an area of approximately 10 hectares, with the labor of only two men. Their only tasks will be to regulate the water discharged through the windows, effect line changes and other water management operations during irrigation.

The method of furrow irrigation is most common in the Brazilian semi-arid region and is characterized by the application of water through a system of long furrows, with inclines varying from 0.2 to 0.5%. These furrows are open at the ends to make it possible to regulate the discharge of the water into the areas of the plants.

In this particular case, EMBRAPA has introduced a number of adaptations that have made it possible to expand the use of irrigation even in regions were water supplies are short. The adaptations consist of the introduction of a zinc sheet gate at the end of the furrow, making it possible to open and close the furrows and thus control discharge. The gate is installed in such a way that an 8 cm sheet of water is formed inside the furrow. The advantages of this system are greater efficiency in the application of water and receding time, with considerable reductions in water losses due to artificial runoff at the end of the furrow and in pumping costs.

Of the more than 20 thousand deep wells that are used to supply underground water to the semi-arid region, 85% of them are located in crystaline soils, characterized by discharge of 4 m^3/ha and salinity of 0.5 to 4 g/l.

The crystaline formation covers 45% of the region and has an underground water capacity estimated at 50 to 250 million m^3/year. However, due to the quality of the water, only a small part can be used and even this share is reserved exclusively for animal consumption.

Tests based on the use of deep well waters, with total salinity levels of 9.1 g/l have shown that it is feasible to utilize saline water in the production of foodstuffs, with the condition that systematic or complementary irrigation systems be utilized. In the latter case, cultivation takes place during the rainy season and the irrigation system is only used when there is a scarcity of water, provoked by long periods without rain during the vegetative cycle of the crop. The salts accumulated in the soil profile as a result of complementary irrigation are leeched by the rain and carried below the level of the roots.

The association of this system with water impoundment systems "in situ" (furrows and humps in contours) can reduce the need for complementary irrigation, without jeopardizing the productivity of the crops.

2 Fertilizers

At the present time, the Brazilian fertilizer industry is fully prepared to make the most varied forms of solid and liquid fertilizers in NPK – Table 2.

Internal production of each type of fertilizer – nitrogen-based, phosphate-based, thermophosphatic, NPK, solid, liquid – is as follows:

– Nitrogen-based

The distribution of national production of ammonia on a company by company basis, showing the raw material used by each, production capacity, the volume of 1983 output and the final products turned out on the basis of ammonia are all shown in Table 3.

There are six factories in Brazil that produce ammonia for purposes of fertilization. Four of these turn out urea; one produces nitric acid and ammonium nitrate which is mixed with dolomitic lime and marketed in the form of nitrocalcium (26-0-0), while the other produces nitric acid, ammonium nitrate and DAP.

Aside from the fertilizers that are directly produced at the plants that make ammonia, there also exists ammonium sulphate, a subproduct of the process used in making caprolactam and methyl methacrylate or even of the production of the steel industry (on a lesser scale).

One industry produces synthetic ammonium sulphate.

– Phosphate-based

TABLE 2. Structure of the fertilizer industry in Brazil.

Raw materials	Intermediate products	Simple fertilizers
Natural gas	Nitric acid	Urea
Petroleum		Ammonium nitrate
Naphta		Nitrocalcium
Heavy oils	Ammonia	Ammonium sulfate
Residues		Ammonium phosphate
		Super simple
Sulfur	Sulfuric acid	Super triple
	Phosphoric acid	Thermophosphates
Phosphatic rock		Potassium chloride
		Potassium sulfate
Potassic rock		
		· NPK

TABLE 3. Brazilian ammonia production for fertilizer purposes.

Company	Locality	Capacity t/year	Raw material	Products
Ultrafértil	Cubatão (SP)	29,700	Residual gas	Nitrocalcium
	Piaçaguera (SP)	149,820	Naphta	Ammonium nitrate and DAP
	Araucária (PR)	396,000	Asph. residues	Urea
Nitrofértil	Camaçari (BA) I	66,000	Natural gas	Urea
	Camaçari (BA) II	299,310	Natural gas	Urea
	Laranjeiras (SE)	299,310	Natural gas	Urea
Total		1,240,140		

Source: Raw materials and fertilizers. PETROFÉRTIL – PETROBRÁS Fertilizantes S.A. - Information yearbook.

In recent years, Brazilian production of phosphatic concentrates has increased sharply, making the country self-sufficient in this input. This increase can be explained by the fact that it has become feasible to mine deposits of igneous rock, using a technology that was developed for the purpose of processing these rocks. This technology has already been exported and Brazilian technicians are now considered to be experts in the field, and among the best in the world. Table 4 shows the present distribution of the production of phosphatic concentrates, on a company by company basis.

Table 5 shows the installed production capacity of simple phosphatic fertilizers, demonstrating that 75% of these products are obtained on the basis of phosphoric acid, an input in which Brazil is 95% independent of the international market.

– Superphosphates

Superphosphates are the principal source of phosphorous in Brazil, and 23 different companies now turn out this product.

It should be noted that some of these production units were totally projected in Brazil, on the basis of Brazilian technology.

– Thermophosphates

Despite the fact that thermophosphates represent just 2% of Brazilian production of P_2O_5, this product has attracted increasing interest and it is now expected that the participation of this type of fertilizer will increase sharply in the near future. This fact is the result of two elements:

- Thermophosphates are fertilizers that are suited to the conditions of a major part of Brazil's tillable land (acid soils in tropical regions);

- Brazil is already technologically prepared to develop projects involving the production of calcined or fused thermophosphates.

An added advantage can be found in the fact that thermophosphates represent a means used in making phosphates soluble, independently of the use of sulfur (which is totally imported).

– NPK Fertilizers

NPK fertilizers are marketed in Brazil exclusively in the following forms: bulk blends, complex granulated fertilizers and liquid fertilizers.

TABLE 4. Brazilian production of phosphatic concentrates.

Company	Locality	Production		
		Concentrate (t) installed capacity (+ P_2O_5)	P_2O_5 Content (%)	P_2O_5 (t)
Serrana	Jacupiranga (SP)	430,000	36	154,800
Arafértil	Araxá (MG)	680,000	36	244,800
		50,000	28	14,000
		200,000	24	48,000
Fósforo	Catalão (GO)	500,000	38	190,000
Goiásfertil	Catalão (GO)	620,000	38	235,600
Fosfértil	Tapira (MG)	1,100,000	36	396,000
Fosfértil	Patos de Minas (MG)	200,000	24	48,000

TABLE 5. Installed capacity for production of simple phosphatic fertilizers (10^3 t of P_2O_5).

Product	Capacity	Production/1982 t P_2O_5
Simple superphosphate	742	238,311
Triple superphosphate	-	277,838
MAP	182,040	437,114
DAP	365	195
Partially acidulated phosphate	244 (product)	-
Thermophosphate	37	21

– Solid fertilizers

There are now about 150 plants in Brazil that produce bulk blends. The complex fertilizers are obtained through granulation, with or without chemical granulation. Of these companies, 26 use varying production processes, as shown below:

- granulation in drums, plates and plates with the use of the pugmill;
- use of the pipe-reactor (inside or outside the drum);
- use of the pre-reactor, etc.

– Liquid fertilizers

The production of liquid fertilizers is relatively recent in Brazil. The first production units were founded about ten years ago to turn out foliar fertilizers and, about six years ago, production of liquid fertilizers began.

Aside from this, one should also recall that many sugar and alcohol mills make intensive use of the residues of their production processes mixed with potassium fertilizers, as well as liquid forms for use in the soil, at planting time.

These formulations have been prepared in a reactor using such raw materials as sulfuric and phosphoric acids to attack the phosphatic rock. This is followed by neutralization with warm water and the addition of potassium chloride to complete the formulation.

3 Special Services

Among special services are included implementation, management and coordination of the organizational complex of agricultural research.

Today, heavy investments are being made in the area of rural management through linear programming. This has produced highly advantageous results for both the rural producer who is part of the Cooperative System and for the nation's economy as a whole.

One can affirm that this new stage in the process of agricultural development based on intensive use of cybernetics has already produced highly positive results.

In general, these programs have the aim of aiding in the management of rural properties, improving managerial efficiency, by providing rapid responses to a series of factor that affect the rural economy, as well as the more efficient allocation of available resources.

Among these programs, the most important is PROFAZENDA.

3.1 PROFAZENDA

PROFAZENDA is a computerized system that analyzes the property as a whole. It shows the producer what is the best alternative in the use of his resources, in such a way as to maximize economic returns. This analysis is based on the prices of inputs and products and the technologies and resources that are available on the property. This system can be utilized both by large and small producers and provides them with that type of business perspective that is indispensable to those who are truly intent on increasing their net revenues through the optimization of the resources available to their undertakings.

The information is supplied by the farmer by filling out a specific form. In the first place, general information on the property itself is gathered (taking the property as a whole), followed by information on each of the crops cultivated, including available resources, technologies and the prices of products and inputs. The principal areas of general information are the number and types of machines, equipment and improvements that exist on the farm; categories of soil existent on the property; systems of production marketing; values of the machines, equipment and improvements; working days per half-month or month; availability of permanent and temporary manpower, and the respective costs. The information on the crops includes area; periods of soil preparation, planting, crop treatment and harvests; use of inputs, machines, manpower, animal labor, etc., broken down for each crop, together with the respective prices, average yield and variations and technological coefficients.

PROFAZENDA supplies a series of written reports to aid the farmer in the decision-making process. It compares earnings, losses and the individual budgets of each crop. It also identifies the factors that restrict the growth of activities on the property. The program provides information on what and how much to plant, what is the average income and how to maximize it, through more efficient allocation of resources existent on the property. It projects the use of machines, equipment and labor for each activity and crop, while specifying the best days for planting, for crop treatment and harvesting. It also makes it possible for the farmer to decide on the perfect utilization of modern inputs in relation to each crop. Finally, it elaborates comparative analyses between production costs and minimum prices.

PROFAZENDA also analyzes the impact of different levels of interest rates. It tests the introduction of alternate crops and technologies and evaluates the efficiency of tractors, machines, harvesters and animals in the preparation of the soil, planting and crop treatment. Various technologies that use greater and lesser amounts of manpower.

The program examines the quantity of land needed for purchase or leasing, through an analysis of opportunity costs. In summary, the program makes it possible for the farmer "to plant in the computer". Utilizing simulations of alternative technologies, the producer obtains answers as to how to make better use of the factors existent on the property, in such a way as to maximize his income.

PROFAZENDA is available to any country that is interested in commercial exchanges with Brazil. It should be mentioned that the program has been thoroughly validated on the basis of almost countless Brazilian properties.

3.2 Other Programs

During the course of years, Brazil has developed and accumulated knowledge in the area of information, documentation, publishing and dissemination of technologies. Today, EMBRAPA is in a position to offer other countries a line of software to be used in the manipulation of bibliographic data bases in the area of agriculture and like sciences, together with know how in the elaboration of selective catalogues that can be used to control book and periodical catalogues, and in the elaboration of a program of informative summaries.

There is no doubt that EMBRAPA can now provide advisory services on the structuring of a publishing policy, the development of software fot the control, dissemination and transfer of the generated technologies and implementation of a program of technological transfers.

By the fact that it uses available technological information in a highly efficient manner, the transfer of these technologies can create or increase capacity in developing countries, aiding in raising the standards of living of the local population through increased production of foodstuffs. The basic question is to know how to use the technologies that have been developed by a country like Brazil, when these technologies are to be utilized in countries with similar edaphoclimatic and socio-economic conditions.

In the coming years, imports of food and other agricultural products by the developing countries will be limited by the availability of exchange reserves. At the same time, the shipment of goods from one country to another is becoming an increasingly expensive undertaking. Consequently, one must seek to increase the flow of technology which, aside from being cheaper, provides the importing company with a permanent source of knowledge.

Thus, technological innovations that originate in Brazil can generate new trade and investment opportunities among the nations of the third world, particularly in the light of the fact that all countries have specific technological needs and interests.

IV - Technological Development in the Storage Sector

The Brazilian Storage Network is composed of units with varying types and characteristics. This is the result of the diversification of the Brazilian agricultural structure and the vast area over which this network is distributed. Consequently, in terms of conception, characterization, objectives and technologies, the Brazilian storage system is highly varied.

The coordination of grain storage policy is the task of the Companhia Brasileira de Armazenamento – CIBRAZEM (Brazilian Warehouse Company), founded in 1963 and subordinated to the Ministry of Agriculture.

CIBRAZEM's principal task is to develop and participate in federal agricultural production programs, while installing storage facilities in those areas that normally do not possess static storage capacity.

In recent years, the question of installing storage units has been the subject of detailed studies of the type of storage and the products to be stored, without even mentioning the question of the transformation of bagged storage systems to bulk storage.

Brazil's total static capacity is in the range of 60.5 million tons. The government network has capacity for 11.5 million tons, while cooperatives can store 15.3 million tons and the private network can store 33.7 million tons. A breakdown of the overall total shows 33.7 million tons of capacity in terms of conventional storage (bags) and 25.3 million tons in bulk storage capacity.

1 Storage Units

1.1 At Farm Level

These are generally low capacity and dynamic storage units located in the areas of production (farms, granges, etc.).

These can be bulk or bag units with very simple and clearly defined characteristics and a slow rate of movement.

Operations are based on the minimum equipment needed for cleaning and drying the production of the farmer. The normal operating cycle or basic flowchart is as follows: reception – cleaning – drying – fumigation – storage and dispatch.

Bulk storage units at the farm level are normally composed of metallic cells made of galvanized steel. In the case of conventional storage, the most common types are made of brick and morter, galvanized steel, and so forth, including just about any material that is easily available in the region. Soybeans, wheat and corn are stored in bulk form.

1.2 Collectors

These installations are normally located in the production areas and vary in size depending on the flow and type of grains in the region.

Normally, their basic lay-out is as follows:

– Area of administration and control;

– Area of parking and weighing;

– Area of storage (including reception and dispatch);

– Area of processing (cleaning, drying and fumigation).

Most of these units are made of concrete, galvanized steel, brick and mortar or any other type of available material. They are used in the bulk and bag storage of production for short and medium periods of time (up to 6 or 8 months).

These facilities have driers, cleaning machines and most of them (particularly in the case of bulk storage) possess temperature control and aeration systems. This is particularly important when one considers the fact that most of the grain arrives at these units with high humidity and dirt content. Consequently, these products must be subjected to processing so that they will be suitable for storage.

1.3 Intermediaries

These installations are located in strategic areas of the country and along export corridors. Normally, the products they receive are already in a suitable state for storage and do not have to be processed (cleaning and drying).

These facilities act as storage centers and can keep the products for more flexible periods of time. Their principal function is to regulate and structure flows that demand terminal and port facilities and their rate of operational movement is normally medium to high.

1.4 Terminals

These are high capacity, rapid operating units situated near ports or highway and rail terminals and are designed to withstand the pressures of the intermediate flows.

These units receive the products from the collector units, cooperatives and intermediary units, etc.

1.5 Ports

Located in port areas where loading and unloading takes place. Normally, they consist of large capacity static and dynamic silos, since the products are kept in these facilities on a temporary basis. The operational pace of these units is very rapid and they have the objective of regulating export and import flows. These can also be considered as terminal units.

2 Characteristics of the Storage Units

2.1 Conventional Storage – Bags

These installations are used for bagged, elaborated, processed and industrialized products. They have been steadily improved through the introduction of new technical and conceptual details, principally with regard to the conservation of the products to be stored. The materials that are most commonly used in the construction of these units are galvanized steel plates and brick and mortar.

In recent years, the most commonly acquired units have been modular metallic storage facilities since they can be transported and assembled in just 40 days, making it possible to reduce the period of time needed for meeting the harvest needs of farmers. These units can also be incorporated into other types of storage units, being placed at the end of warehouses, in the lateral sense or even being used as administrative and other types of units.

2.2 Bulk Storage

These are grain storage units that are characterized as separate cells, often hermetically sealed one from another. The system makes it possible to minimize environmental influences on the storage area.

The silos have a service tower (central or lateral) in which the bulk product circulates over predetermined circuits, depending on the basic operation in question (reception, cleaning, expurgation, stocking and dispatch). The basic objective of these facilities is to combine a dynamic operational system with the maintenance of quality control and the conservation of the moved or stored product.

2.2.2 Vertical Silo

The name vertical silo has been given to these facilities by the fact that the height dimension is greater than the diameter at the base of the silo. It is a type of compartmentalized unit that utilizes varying cell formats to form a highly variable unit that is usually in cylindrical form. Normally, they are constructed in reinforced concrete (self-fitting forms) and other types of material.

The Buffalo silos are also classified among the vertical silos, despite the fact that their conception and characteristics are different from the cylindrical silos. These are characterized by four-sided and inclined cells arranged in a specific format within a building, which also houses the entire support infrastructure, such as offices, scale, machines and equipment. These units have a number of advantages, particularly as regards savings on energy, less need of manpower and the fact that the basic movement of the grain is done by the force of gravity.

2.2.3 Batteries

These are groupings of normally metallic cells that are placed either individually of in groups around a central reception/pre-processing unit. The capacity of these units varies, making it possible to adapt the modules to the needs of the different types of rural enterprises.

The principal characteristic of this type of unit is the composition of the metallic, cylindrical cells that are available with flat cylindrical bottoms, with a processing center (cleaning and drying) installed at ground level. The need for varying static capacities is common in intermediate, collector and on-farm facilities.

2.2.4 Grain Warehouse

In this type of unit, storage is done in the horizontal sense, using one or more compartments, depending on whether the unit is provided with divider walls. Normally, the lateral walls are made of reinforced concrete made at the site or pre-fabricated. The unit has a metallic roof and a flat bottom or one in a "V", "W" or "semi V" format.

2.2.5 Flat Storage Unit

The flat storage unit is manufactured in Brazil and has the basic conditions and flexibility for the storage of bulk or bagged products. In order to provide this unit with more intensive use and greater yield, it can be connected to a structure for the reception, processing and dispatch of the goods. In this way, the unit will be fully prepared for those cases in which there is a need for the complete operation cycle that is characteristic of the collector system. However, the unit can also be prepared only for reception and dispatch, particularly when it is located in an export corridor and is involved in export and import operations (intermediate and/or terminal). The period needed for assembly of these units is approximately 40 days after the land area has been prepared. This flexibility makes it possible to utilize the units in emergency situations. Since these units are made in modular form (5 m), their capacities can vary greatly depending on need. The most common unit has a capacity of 10,000 tons.

2.3 Emergency Units

2.3.1 Structural Warehouse

This unit is normally used in areas only recently incorporated into the productive structure, when it is necessary to increase static capacity or to meet an emergency situation.

After the land has been prepared, assembly time is a maximum of 10 days. At any time after installation, the unit can be rapidly moved to an area where it is in greater demand. Operational and maintenance costs are practically insignificant. The Unit consists of a drawn aluminum structure covered with polyester screening which, in turn, is covered in PVC. The floor is often compacted earth covered with rice husks, plastic or just about any other available material.

2.3.2 Underground Storage in Plastic Silos, Drums and Corn Cribs

The latter three types of units are used mostly by small farmers, due to their low cost.

Nominal capacity varies, though the most common is 2,400 tons.

3 Machines and Equipment

Storage units – and principally those located in production regions – possess and need processing centers with all of the machines and equipment needed to ensure that the products are suitable for storing.

3.1 Driers

Driers are divided into movable and stationary, with continuous or intermittent operation. The most common is the cross flow system adopted by Brazilian manufacturers.

3.1.1 Basic Characteristics

– Capacity

- from 4 tons/hour up to the individual limit of 40 tons/hour or multiples of 40 tons/hour. Drying capacity is based on the reduction of humidity from 18% to 13%, with relative air humidity of 60% and an environmental temperature of 20°C.

– Heat Source

- connected to a furnace that burns logs, rice husks or any other type of material that is capable of generating enough energy to heat the atmospheric air to a temperature that is sufficient for drying the grain and seeds. Fuel oil furnaces have fallen into disuse as a result of national energy policy.

There are other types of driers in which technology has not yet been totally defined, principally from the practical point of view. These deserve mention by the fact that they represent efforts now being made to provide small and medium farmers with alternative driers, that will operate at low cost and will be easy to maintain.

Among the options available to producers are the coffee and cocoa driers that utilize solar energy or low cost brick furnaces. These driers were developed by Centro Nacional de Treinamento em Armazenagem – CENTREINAR (National Center of Training of Storage).

3.2 Pre-Cleaning and Cleaning Machines

Through a system of air and filtering, these systems separate the grain from impurities. Each of the machines is equipped with specific filters for each type of product to be cleaned.

The filters work on the basis of vibration and constant horizontal movement. This equipment is available in many capacities and normally is made compatible with the production of the drier so as to transform the two operations into a smooth and efficient process.

3.3 Vertical and Horizontal Transportation Equipment

These include conveyor belts, redlers, continuous thread equipment, bucket elevators, pneumatic suction equipment, etc. Each type of equipment has its own specific characteristics and is designed with a particular objective in mind.

Another important innovation is to be found in the bag stacking equipment which is now fully adapted to the transportation of bulk products through the simple transformation of the flat platform into a concave platform, making it possible to use the equipment with a normal conveyor belt.

3.4 Laboratory Equipment (for classification of farm products)

In the classification of vegetable products, there is an enormous list of equipment that is needed, including magnifying glasses, pincers, grain scales, scales, universal humidity measuring instruments and so forth. The universal humidity measuring equipment manufactured in Brazil has characteristics that have been fully adapted to the conditions of the country. Its basic characteristics are as follows:

- used for cereals, grain, seeds and other products;
- direct reading of humidity percentages ranging form 8% to 40%. Temperature correction through the use of a built-in thermometer;
- generates its own energy through a manual megohmeter directly connected to the body of the device;

- operates on the basis of pressure through a system of pressing and crushing of grain, with the aid of a ratchet.

At the present time, Brazil possesses all of the technology needed for adequate storage. It has the CENTREINAR, which was created specifically for the training of human resources in the management and operation of storage units.

4 Cooperation, Consulting Services and Technical Assistance

In this area, mutual assistance can be rendered by technicians from CIBRAZEM and CENTREINAR. Among the types of cooperation, consulting services and technical assistance that are available, the following deserve mention:

- formulation and elaboration of operational norms;

- operation of storage units;

- organization of personnel improvement and training;

- guidance in the conception and execution of storage unit projects, including analysis;

- technology in the implementation, operation and management of storage units;

- guidance as to the types of storage units, machines, equipment and accessories that are necessary;

- phytosanitary treatment of warehouses and stored grain, with emphasis on the control and combatting of rats and insects;

- guidance in the carrying out of basic tests, with the objective of adopting a specific operating system;

- methodology applied to the control, analysis, and stock statements etc.;

- conception and operation of mini commodity exchanges of the CICOA typa;

- any other area in which there is a need for knowledge and information and which is related to the area of storage as a whole.

V - Machines and Tractors

Brazilian agriculture entered the cycle of mechanization in the 1960s, when Brazil began to produce its first farm tractors. Up to that time, tractors and harvesters had to be imported and, according to a census carried out by the Fundação Instituto Brasileiro de Geografia e Estatística – FIBGE, the total number then in operation in Brazil was about 60,000.

At that time, the Brazilian rural environment was marked by a strong migratory flow from the interior to the cities. This was the start of the Brazilian industrial cycle, which created demand for skilled, semi-skilled and unskilled manpower. The latter was in great demand in the cities, particularly in the building industry and other less demanding services.

Migration to the cities meant higher salaries, better living conditions, and improved health and education for the next generation of the migrant family.

The rural area, at that time, had suffered a series of setbacks, best exemplified by the cotton crop which demanded a high volume of human labor but which lost its position to synthetic fibers, beginning in 1952. Year by year, the coffee crop witnessed declining incomes as more and more countries entered the market.

The effort to create an automotive industry became a reality in the late 50s and early 60s. This led to a sharp movement of manpower into other industrial sectors, commerce and services and had the effect of hastening the migratory flow.

Parallel to this, one can state that, to a certain extent, agricultural mechanization was induced, since the substitution of manpower and animal traction carried with it the advantages of low interest (subsidized) and credit for tractors and other types of farm implements. At the same time, one should recall that the costs of petroleum derivatives was still quite low.

During the first stage of this process, the tractor was the major item, since it was used to offset the loss of manpower in the preparation of the soil, plowing and grading. This demand was rapidly met by the industrial sector. The second phase - consisting of planting and cultivation – was postponed, since there was still sufficient manpower for these operations. In this case, the use of animal traction was still significant, since the necessary animals, farm implements and adequate manpower were still available.

The third phase – harvest – reflected a period of higher costs which led farmers to go to villages and adjacent cities in search of seasonal labor for specific tasks: harvesting of coffee, cotton, sugarcane and other regional crops. This phase continues to the present day, particularly in the cases of sugarcane, oranges, coffee and cotton.

Crops such as oranges, beans, tomatoes and others crops pertaining to the sector of olericulture utilize low levels of mechanization during the harvest period, since manual harvesting still has a cost advantage.

Most of the irrigation systems developed in Brazil were based on technology transfers from other countries and were incorporated into existent know how. Electric and diesel engines have been commonly use to activate these irrigation pumps.

At the present time, the farm sector has about 530,000 tractors with average power of 58 HP and approximately 52,000 self-propelled harvesters, with average power of 100 HP and a significant number of irrigation pumps, threshing machines, triturating equipment etc., almost all of which are powered by diesel engines. Totally mechanized crops such as soybeans demand between 60 to 80 liters of diesel oil per hectare per vegetative cycle, including preparation of the soil, planting, cultivation and harvesting.

The growth of mechanization in Brazil can be measured in terms or effective power per hectare. Table 6 shows how the power supplied by tractors and harvesters has greatly surpassed other forms of energy available to farmers. However, despite the fact that, between 1960 and 1980, there was a sharp variation in effective installed power per hectare, the present levels are well below those found in some developed countries. This is shown in Figure 1, based on data supplied by FAO. The correlation between effective power and aggregate productivity should be understood as one of the items included in the modern inputs of the agricultural sector. Thus, the use of mechanization has been closely followed by the use of selected seeds, pesticides, fertilizers, soil correction methods – all of which are factors that increase productivity.

With respect to irrigated area, one must provide sufficient power to pump the water needed during the vegetative cycle of the crop. The power is a function of the edaphoclimatic conditions of the locality, the crop to be irrigated, the system of water impoundment, fertilization and water distribution. In general, installed power ranges from 0.5 to 2.0 HP per hectare and it is common for the energy needed to pump water to a single hectare during one vegetative cycle to surpass the level of 1,000 liters of diesel oil, or its equivalent in electrical energy.

On the basis of the degree of mechanization now existent, consumption of petroleum derivative fuels in the Brazilian agricultural sector can be estimated at

Average
aggregate
productivity
of
principal
crops
(t/ha)

Egypt
Europe
USA
Israel
Brazil (1960/1980)*
Developing
Countries (5.5 t/HP)
Africa
Asia
India

Japan
Developed Countries

. Key
Principal crops: cereals, oilbearing crops, potatoes, onions, tomatoes, saccharide products (equivalent in sugar), cassava (Brazil).

. Total effective power: (human + animal traction + machine power)

Effective Power per Hectare (HP/ha)

FIG. 1. Average productivity and rate of mechanization in diverse countries (Ref. FAO Yearbook, 1964 to 1971. IBGE-Brasil).

approximately 3.8 billion liters per year, or about 18% of the nation's consumption of diesel oil.

TABLE 6. Summary of Installed Power in Brazilian Agriculture.

	1960	1970	1975	1980*
Area cultivated (ha)	28,712,209	33,983,796	40,001,358	49,000,000
temporary (ha)	20,914,721	25,999,728	31,615,963	40,000,000
permanent (ha)	7,797,488	7,984,068	8,385,395	9,000,000
No. Tractors (unit)	61,324	165,870	323,113	530,691
1. Power (MHP)	3.04	9.12	18.91	31.31
Traction Animals (un.)	1,500,000	2,500,000	1,500,000	1,500,000
2. Power (MHP)	1.0	1.50	0.90	0.90
Active Manpower (un.)	12,165,000	13,090,000	13,848,000	14,749,000
3. Power (MHP)	1.22	1.31	1.38	1.47
Electrical Energy, Rural Connections	-	75,000	112,500	166,000
4. Non-Residential Power (MHP)		.42	.63	0.93
Harvesters (self-propelled)	-	15,000	30,000	52,000
5. Power (MHP)	-	1.10	3.0	5.2
Total Power (1)+(2)+(3)+(4)+(5) (MHP)	5.26	13.45	24.82	39.81
Specific Power (HP)				
a. Per Worker	0.43	1.03	1.79	2.70
b. Per ha. Cultivated	0.183	0.396	0.621	0.812
Specific Area (ha)				
a. Per Worker	2.36	2.60	2.89	3.32
b. Per Tractor	468	205	124	92

Sources: FIBTE, ANFAVEZ, MME-IPEA
* Estimates
MHP = 10^6 HP

It is well known that, today, the use of diesel oil has been an important factor in restricting the nation's possibilities of reducing oil imports, given the maintenance of the present refining structure that makes it possible to produce about 32% diesel oil on the volumetric basis of refined petroleum.

At current international prices, freights and the present petroleum refining structure, the domestic price of diesel oil represents about 10 to 15% of the basic cost values, for most mechanized Brazilian crops. This calculation does not take account of irrigation costs.

Aside from the high costs of petroleum derivative fuels, it is also necessary to supply the agricultural sector with alternative sources of energy, capable of avoiding a collapse should there be an interruption in the supply of imported oil.

Among the alternatives that are considered to be feasible substitutes for diesel oil in agricultural machines, agricultural research – in cooperation with the private sector, including manufacturers of farm machines and motors, and other government entities – is giving particular attention to the following:

- *hydrated alcohol in Otto cycle engines*;
- hydrated alcohol in diesel cycle engines, equipped with a double injection system to substitute 80% to 90% of the diesel oil;
- mixtures of 30% of ethylic or methylic esters of vegetable oils and 70% diesel oil;
- ethylic or methylic esters of vegetable oils as total substitutes of diesel oil;
- charcoal gasogene in diesel cycle engines, to substitute 70% to 80% of the diesel oil use in farm tractors;
- gasogene powered by timber or charcoal, in stationary Otto cyle engines;
- gasogene powered by timber or charcoal, in stationary Diesel cycle engines, substituting 70% to 90% of the diesel oil;
- biogas (methane) in stationary Otto and Diesel cycle engines, utilizing a diesel oil injection system to produce a 10% to 20% mixture;
- electrical energy (hydroelectric) in irrigation system, to substitute diesel oil.

Other options that can substitute the use of diesel oil in Brazilian agriculture either partially or entirely represent only local or individual contributions and, thus, are not particularly significant. Among these, we should mention:

- animal traction as a substitute for tractors;
- compressed biogas (methane) for use in tractors and vehicles;
- mixture of up to 7% anhydrous alcohol in the diesel oil supply;

– hydrated alcohol with a combustion acceleration additive (4% to 5% ethylene glycol nitrate).

Among the aforementioned alternatives, some are already considered technically feasible and have certain economic advantages as substitutes for diesel oil.

One should emphasize that, independently of the energy source utilized, fuel consumption in the agricultural sector can be reduced through greater efficiency in the use of mechanization. Among the factor's that can produce fuel savings of as much as 30%, we should mention maintenance of the equipment, correct tire pressure, suitable selection of the tractor/implement, correct choice of work speed and adequate operator training, etc. In certain crops and under certain conditions, minimum cultivation techniques, direct planting, etc. can mean savings of as much as 50% in fuel consumption and hours.

In the last four years, among the alternatives that have been developed as diesel oil substitutes in Brazilian farm machines, the most important are: alcohol-power tractors, gasogene in farm machines, diesel engines powered by modified vegetable oils and biogas engines. All of these alternatives have been receiving the full support of the research sector and are being field tested.