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FARMING SYSTEMS RESEARCH AT THE BRAZILIAN NATIONAL CORPORATION FOR AGRICULTURAL RESEARCH

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FARMING SYSTEMS RESEARCH AT THE BRAZILIAN NATIONAL CORPORATION FOR AGRICULTURAL RESEARCH-EMBRAPA*

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I. INTRODUCTION

Originally, this study was written as a contribution to the discussion of "The Review of Farming Systems Research at the International Agricultural Research Centers, CIAT, IITA, ICRISAT

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and IRRI"*, held at the Technical Advisory Committee Farming Systems Research Workshop, May 29-31, 1978, in Nairobi, Kenya. More specifically, it was prepared as a contribution for the discussions of Sessions II and III of the Workshop, on Research Methodology and Conduct of Farming System Research and the respective roles of International Agricultural Research Centers and Regional/National Institutions, respectively.

The study does not intend to be comprehensive. It is more a descriptive summary of some of the main farming systems research (FSR) activities currently developed at EMBRAPA. It is divided into four parts. The firts three parts are devoted to the presentation of FSR activities in the regions of the Semi-Arid Tropics, Humid Tropics, and "Cerrado", respectively. The base for analysis within each of these regions are EMBRAPA's so called resource research centers. The last part summarizes some of the FSR and/or systems component research currently underway at some of EMBRAPA's commodity research centers.

II. FSR AT THE SEMI-ARID TROPICS

1. Introduction

EMBRAPA's resource research center for the Semi-Arid Tropics (CPATSA) was established to promote and maintain the agricultural development of the Semi-Arid regions of Brazil's Northeast. This center is responsible for

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* Respectively, Centro Internacional de Agricultura Tropical, International Institute for Tropical Agriculture, International Crops Research Institute for the Semi Arid Tropics, and International Rice Research Institute.

the development of the new and [illegible] production systems which will be introduced and applied in several areas of the Semi-Arid tropic of the Northeast. The center is also responsible for standardizing new technologies that will be executed by the research network in several regions of the Northeast.

The traditional system of the agricultural production in this region consists of a joint exploitation of agriculture and livestock. Due to a low rainfall and a irregular rainfall distribution, farmers of this region are always facing high risk of parcial or total lost of their production. Recently, irrigation projects, established mainly at the margins of the San Francisco river, have considerably improved agricultural production in the area. However, most of the land is still being cultivated under rainfall cultivation. Consequently, a research program for dryland was initiated by CPATSA for the development of new production system which aim the increase in agricultural production through the use of new technologies. The use of existent resources such as varieties that are drought resistant are being researched taking into account the characteristics of climate, soil and plant. Socio-economic aspects are also being considered in an integrate manner in this research program.

The research program for CPATSA also includes a FSR on management of "Caatinga" and a FSR for irrigated areas.

2. Dryland FSR

Due to the great rainfall variation (from 250 to a 1.000 mm) and to the large [illegible] in vazantes, three systems of cultivations: rainfed, watershed and vazante, are being studied under this project. This research program, associated with the study of drought resistant plants, are conducted

simultaneously by a multi-disciplinary research team. This team is formed by specialists in: agroclimatology, cultural practices, animal production, ecology, economics, agricultural mechanization, hydrology, soil and water management, plant breeding, soil fertility, plant nutrition, physics of soil, and soil-water-plant relationships.

a. Runoff FSR

Objectives

1º) to develop a system of cultivation by runoff that could be applicable to the region of the "Sertão" (annual rainfall from 250 to 600mm).

2º) to determine the efficiency of the water collected in areas without vegetation.

3º) to define the relationships between the water collected and the irrigated area in a given region.

4º) to identify the importance of the soil depth in the irrigated area.

Methodology: An area of 17 hectares was chosen for the instalation of the runoff FSR experiment. Two areas of 4 hectares each were cleaned and levelled by tractor. Two tanks (45 m X 45 m X 3m), with a capacity of 6.025 cubic meters each, were built to collect water from the superficial runoff. The slope of the area varies from 1.5 to 2.5%. Two plots with 40m by 200m are being used for comparison (native vegetation). Three areas with different soil depth, 30 to 50cm, 40 to 60cm, and 70 to 100cm, were prepared for planting corn and beans. The study of drought resistance varieties is conducted within these areas.

Objectives:

1º) to develop a planting system in watersheds that could be used in the region of the "Agreste"(annual rainfall between 600 and 1.000mm).

2º) to compare the traditional cultivation systems with the watershed system.

3º) to compare the traditional cultivation system with a ridge planting system.

Methodology: An area of 8 hectares, containing two tanks was chosen for this experiment. The system of preparing the soil for ridge planting will be compared with the traditional system.

The area is divided into four small watersheds with 1.5 hectares each. The system of ridge planting with supplementary irrigation, introduced by ICRISAT, is being used in two watersheds with water collected into the two existant tanks. The other two watersheds will be used for the traditional cultivation system without supplementary irrigation. The runoff water as well as the sediments will be measured in each of the two watersheds. Inter-planting of corn and beans is used in the four watersheds with similar densities and distances (corn with 2.5m by 1.5m and beans with 0.7m by 0.2m).

c. Vazante FSR

[illegible] first one, with the objective of specifying a system of vazantes, is done in a private reservoir in the Northeast. The level of the water will be

register weekly, once during the rainy season and twice during the dry season. A typical planting system for mixed production of grains, vegetables, fruits, and pastures, is being established at the upward and downward margins of the reservoir. The literature indicates that it is possible to cultivate fruits and forest; also, the development of fishing and recreational activities, among others, are aspects that can be developed under the system of vazantes.

The second study tries to measure the effects of soil management on water conservation. Specifically, it aims to reduce losses by the evaporation of the water through soil management, Also it will test the efficiency of planting in narrow ridges. The methodology for this experiment consists, upward the reservoir, in the construction of terraces and of a set of small tanks. Downward the reservoir a system of planting on narrow ridges, that is irrigated with the water coming from the reservoir, is being tested. The production obtained will then be compared with the traditional system of the region.

d. Drought resistance research

Objective: to identify the adaptation of the plant to the enviroment.

Methodology: this experiment will relate the development of the plant and the economic production with the variations of the climate, soil and the characteristics of the plant. Many parameters will be taken in account during the growing period of the plants. Among them, the following parameters can be mentioned:

1º) Climate: Rainfall, evaporation, relative humidity maximum and minimun temperature, light intensity,

solar radiation, wind velocity, etc.

2º) Characteristics of the soil: fertility, depth, water in the soil, and apparent density.

3º) Characteristics of the plant: species,varieties and types of plants, systems of planting, density, distances, rooth growth, nutrients absortion, physiological and morfological aspects, and production.

e. Multidisciplinary research

The research team at CPATSA is developing and standardizing methodologies for the improvement of the dryland FSR program. Other experiment stations of the system of EMBRAPA in the Northeast will conduct a research program having as basic instruments the methodologies developed at CPATSA. It is important to mention that this research is looking for a production system which will integrate agriculture and animal production in an operational scale, reflecting the current systems of production.

The research project for identification of drought resistant varieties will be developed within the Runoff FSR. Three crops will be tested: corn, beans and millet. The varieties that will show more resistant to drought will be recommended to be studied by the plant breeders. To make easier the work of the researchers in this program for dryland, during the first year, factors such as animal production, breeding, agricultural mechanization, and deseases control, will not be implemented. The preparation of the land will be equal for all of the experiments.

The economic analysis of the three crops of this study will be compared with the systems that are

used by farmers, giving an idea of what can be done in the future with respect to this system. The multidisciplinary team for this program is formed by specialists in: Agroclimatology, cultural practices, irrigation, water and soil management, soil fertility and plant nutrition, physics of soil and plant physiology.

3. FSR on Management of the "Caatinga"

The objective of this research program are:

1º) To identify an economically feasible technology for farming system activities in areas of the "Caatinga", preserving their ecological equilibrium, through the racional use of natural resources.

2º) To increase the supply of food in the Northeast region, where the deficit in beef production and comsumption is very high.

Several research projects are conducted under this program. Among them, the following can be mentioned:

a. Production systems for goats, developed in a private farm, with the objectives of getting basic information on the performance on the productive and reproductive performance of the herd under natural conditions, and also to identify the factors limiting a better performance.

b. Effects of food suplementations, minerals and vermifuges in critical times of the year, on goats productivity, with the objective of measuring the effects of those variables on the productive and reproductive performance. An identical study with the same objective and methodology is also being conducted on sheeps.

c. Two research projects in the form of a germoplasm active bank (BAG) for native and exotic pastures, with the objective to maintaining, multiplying, characterizing and assessing the use of germoplasm, in order to get the necessary information for a better use of the natural resources on animal feeding in the "Caatinga".

d. Qualitative evaluation of native pastures of the region, having the objective of measuring the seasonal effects (rainy and dry seasons), chemical composition and nutritious value of the native pastures.

e. Comparative study of goats production systems with the objective of measuring and comparing the effects of several practices of management feeding and sanitary aspects of the traditional system of the region, against three different improved systems. The improved systems are for health, food and management. In a total area of 300 hectares (75 hectares per treatment) 30 goats are being studied for each technology. In an additive manner, the traditional system is represented in one of the treatments, then sanitary aspects are added to the traditional system in a second treatment, food in the form of suplementary feeding during the dry season is added to treatment nº 2, and finally management is added to the latter system.

f. Management of the "Caatinga" for beef production in a conservative base.

The objective of this research project is to determine which management practices are capable of giving: a maximun production of desirable vegetal species, density and optimum strength of the plants, maximum water retention, minimum soil

erosion and a maximum of animal productivity. Therefore, this project is extremely concerned about the conservation of the general ecological characteristics of the "Caatinga".

4. FSR for Irrigated Areas

a. Introduction: The Brazilian Northeast has an irrigated area of about 49.000 hectares. It is expected that that area is going to be increased at high growth rate, due to the new projects that are being built mainly in the so-called sub-medium San Francisco river. The main crops in this irrigated areas are related to horticulture, fruticulture, some cereals, and some livestock production.

Taking into account that systems of production currently adopted by farmers have very low productivity and profitability, it is assumed that the manipulation of experimental results so far achieved in the irrigated areas, when consolidated in alternative systems of production, could contribute to raise, via technology, net income of those farmers. However, the fact that those experimental results already available, were generated through conventional type of experiments, in which the enviroment is heavily controlled and conducted in small plots, could make that they were not able to be adopted by farmers, without being tested before in larger areas, and under similar conditions to those of the farmers.

A continuous evaluation of the performance of those production systems, by a multidisciplinary team, working under the system approach, would identify, not only those systems with technical

and economical feasibility, but also the limitations to be studied in a priority research in conventional experiments.

b. Objectives: to evaluate, technically and economically, the performance of the main production systems per crop, already in use at the irrigation project of "Bebedouro", in comparison with the production systems available using new technology. This comparison will then aim to generate improve production system for the settlers of that project, and also to test new methodologies for all the irrigated Northeast. Especifically, this research project, will:

1º) Quantify technical coefficients for the different components of each production system per crop, to make an economical analysis;

2º) Evaluate the performance of the different components of those systems, through a continuous evaluation of the multidisciplinary team, trying to identify the positives and negatives aspects of the production systems considered.

c. Methodology: An area of 9 hectares in the irrigation project of "Bebedouro" was chosen for this study. The crops selected for testing systems of production were: industrial tomato, melon, watermelon, onion, sorghum, and beans. It is important to mention that these crops were chosen because of their economic importance, not only for the settler of this irrigation project but also for all the region of the sub-medium San Francisco river.

Two systems of production per crop will be tested. One is the traditional system representing what the average of the settlers of the project are currently doing, and the other is a modified production system in which the new technologies already available from the experimental results will be added.

The central experiment of the production system will have two treatments with two replications for each crop, being: Treatment A, the traditional production system for the crop; Treatment B, the modified production system for the crop. Each plot will have an area of .25 hectare, ajusted to the irrigation channel of the project.

The statistical procedure for testing the technical and economical efficiency of each production system, will use the "t" test for testing whether there are differences between the average of the plots, obtained by samples. This methodology will allow that each particular research will obtain quantitatives or qualitatives conclusions with respect to the experiment. Many parameters within the following research lines will be observed and measured: soil fertility, irrigation, physics of soil, entomology, plant pathology, planty physiology, weed control, seed practices, cultural practices for tomatoes, melon, watermelon, onion, sorghum, beans, and agricultural economics.

III. FSR AT THE HUMID TROPICS

1. Introduction

EMBRAPA's resource center for the humid tropics (CPATU) was created with the main objective of

[illegible] the creation of new, more profitable, and more permanent production systems in this region. As a research unit, with activities related to natural resources, it is also responsible for the study of the interactions soil-plant-climate and soil-animal-climate, in search for basic solutions for a better development of the systems of production, taking always into account that preserving the equilibrium of the natural eco-systems of the region is one of the most important variables. CPATU develops a concentrated effort in areas strategically chosen in the Amazon region, areas which for the time being are centers of atraction for their potential and facilities, and for the possibilities of giving a faster response to the development efforts.

2. Cropping Systems

Several research projects, envolving different combination and possibilities of cropping systems, defined as a system research component of FSR, are under way at CPATU. Among them, tne following can be mentioned:

a. "Screening"

Under this name, CPATU characterizes a research project for the evaluation and preliminary selection of different multiple cropping systems [illegible]

this research project are:

1º) To determine which production system will be better adapted to the different ecological and socio-economic conditions of the Amazon.

2º) To identify the most important factors influencing the performance of the different production systems under test.

3º) To choose among those production systems that use more efficiently those resources of land and labor, with higher yields and higher benefit/cost ratio.

This experiment was installed in two different places: "Altamira", at the 23th kilometer of the Trans-Amazonic highway, in soils of high fertility, and at "Capitão Poço" in soils of low fertility. At each place there are two replications. Different production systems involving single cropping, inter cropping, delay cropping, sequential cropping, and mixed cropping, were tested with those annual crops that are more common in that region: corn, rice, cow-peas bean, and cassava.

The experimental design for this research project was on sub-divided plots, where 41 production systems were tested in plots of 192 m^2 (8m x 24m). Within each plot, areas of 48 m^2 (6m x 8m) were used as sub-plots for testing different levels of technology for those factors that are supposed to have great influence in increasing production such as weed control and fertilizers. Results for the first year (1977) are under analysis. In 1978, the experiment is being repeated for 36 out of the 41 production systems tested in 1977.

b. "CPATU 1"

Under this name, the research center for the

humid tropic is conducting a research project to study the behavior of different production systems of perennial crops in double cropping. The objectives of this research project can be summarized as follows:

1º) To identify economically feasible production systems in accordance with the ecosystem of the Amazon region;

2º) To identify the ecological differences that may occur by the substitution of the forest by economical perennial crops;

3º) To suggest other options for the utilization of areas with different cropping processes.

The expansion of the agriculture frontier in the humid tropics implies the substitution of the forest by economical cropping systems. The particular characteristics of the regional ecology implies the use of cropping systems coherent with those characteristics. Considering the type of soil more common in the region as well as the natural vegetation, it can be inferred that great part of that enormous area, will be adequated for the production of perennial crops, possibly cultivated under inter-cropping systems. It is also possible that inter-cropping systems will reduce the probability of epidemic dissemination of pests and deseases. In the North of Brazil, perennial crops with great economic importance are: Brazilian nuts, rubber trees, cocoa, "guaraná" (Paullinia cupana), and pepper.

The development of production systems through inter-cropping perennial crops was never studied in the past, and the ecological modifications

and the economical feasibility of those systems, are unknown.

This research project was installed in the two same areas of the Amazon region than the "Screening" project, namely, Altamira and Capitão Poço. The first one belongs to the group of yellow latossols of medium texture, and the second one is a red-yellow podzolic. With the objective of rationalizing those perennial crops, testing tolerance indexes to shadow, verifing the economics of different systems, and permitting the use of an adequated experimental design, the consortium of perennial crops in a two by two manner was used. Rubber trees, Brazil's nuts, and the semi-cleaned forest will provide the necessary shadow for: cocoa, "guaranã", and pepper. (A design of this experiment can be found in the Annex). Other than the perennial crops under inter-cropping systems, the same crops have also been planted under the traditional monoculture system, using the current technology. This procedure will allow a comparative analysis of the inter-cropping against the single cropping system.

The following data has been collected:

1º) Ecological: Variations and modifications of the original ecosystem and relation to the new system. The following parameters are measured: edaphics, as the chemical and pedologic characteristic of the soil, climatics, as temperature, rainfall, humidity, wind, soil temperature, soil humidity, temperature within the systems, among others.

2º) Phenological data of the perennial crops of the study.

3º) Economics: variable and fixed cost of the implantation of the system as well as the maintenance cost during of the first five years of production, to make possible the evaluation of the economics of the different production systems, as well as their relations with other economical and social parameters.

c. "CPATU 2"

Under this name,EMBRAPA's research center for the humid tropic, is conducting a research project for studying the productivity of soils of the Amazon region, as well as ecological changes under different management systems. The main objective of this study can be summed up as follows:

1º) To determine the ecological changes, especially those of edaphic nature, produced by different management systems;

2º) To determine the benefit/cost relationship of different types of management;

3º) To develop a production system that will allow a permanent utilization of the tropical region.

Currently there are two traditional ways of using the soils in the Amazon tropics: the shifting cultivation agriculture and the purely extractive activity of the forest. It is known that effects of both usages, with respect to modification in the forest or ecological changes in the region, are fairly different. Shifting cultivation does not represent a planned agricultural system but a method which is relatively efficient for the subsistence level, especially in areas with low population density. Evidently,the use in a large

[illegible] the introduction into the Amazon region of other models of land use, that are utilized in environments of different characteristics, has not given satisfactory results. This demonstrate the necessity of developing agricultural systems in accordance with tropical ecosystems, to efficiently explore the potencialities of the region, without producing unwanted and irreversible changes in the enviroment. Therefore, this research project has the fundamental objective of investigating several management forms for the Amazon soils. This management goes from the native forest, to a system of intensive use, with a complete change in the vegetal covering. This type of research also allows the study of several management forms that will contribute to improve production systems in terms of productivity, profitability, and preservation of the soil natural fertility.

This research project has also been installed in the same localities than the "Screening" project and CPATU 1. In each locality, the experiment has a total area of 9.3 hectares, being 2 hectares for the production of intensive annual crops in a combination with fallow land; 1 hectare with 4 rubber tree production systems; 1 hectare with 4 african oil palm production systems; 1 hectare with 4 "guaranã" production systems; 1 hectare with 4 cocoa production systems; 1 hectare for regenerating the natural covering; 1 hectare for reforestation; and 1 hectare for studies with pastures.

annual crops (2 hectares) is divided into 8 parts of .25 hectare each. This area is being cultivated

intensively during 2 years with a sequence of rice in December and beans in May and corn in December and again beans in May. After 2 years, only sub-treatment number 1 (.25 hectare) will remain under intensive annual crop cultivation, while the others will remain under fallow. After another 2 years, sub-tratment number 2 will be then also cultivated with annual crops for a period of 2 years, while the rest of the area will remain under fallow. And so on, until sub-treatment number 7 which then will have a period of 14 years under fallow. According to this methodology, it will be possible to verify in which period of time the conditions of the soil were recovered in order to give a profitable agricultural production, and also to study which modifications were observed during the process.

The area of 4 hectares in which 4 perennial crops, typical of the Amazon region, rubber trees, cocoa, "guaranã", and african oil palm, has the following characteristics;

1º) for rubber trees and african oil palm, the objective is to find a management system more economical and efficient for the local conditions;

2º) for cocoa and "guaranã", the objective is the obtention of information about the behavioral and ecological modifications in different management system as well as to give information about the profitability of this crop for different places in the Amazon.

The evaluation of the results will be done following agronomic, edaphic, economical and micro-climatic criteria. It is expected that the data obtained from this research project will produce the necessary information for programming several

land use alternatives and a clear indication about future agro-ecological research for the region.

Evaluation parameters for this research project are as follows:

1º) Agronomic factors: agronomic results will be measured through data on growth and productivity;

2º) Edaphic factors: due to the use of different management systems, edaphic conditions are likely to be more susceptible to changes, mainly of chemical and micro-biological nature. For this reason, prior to the installation of the experiment, the soil was carefully characterized, and periodical samples are collected to check for possible transformations during the experiment.

3º) Economic factors: evaluation of the instalation and maintenance costs of the experiment, and benefit/cost analysis.

3. Livestock Systems

Based on the geological map of the Amazon region, it is estimated that there exists about 30 million hectares of land subject to annual floods. Due to a extremely difficult and expensive drainage, that area does not allow a permanent economic production of crops and beef cattle. Trying to use that potential, EMBRAPA's research center for the humid tropics, established a research program on water buffalos, animals already adapted to those conditions. The general objective of this research program is to improve current production systems as well as the development of new production systems, considering factors such as productivity, profitability and stability of those systems. This program involves

the testing of production systems, research on "satellite" experiments animal breeding, and studies on selected pastures. The program also involves the selection of water buffalos for milk and beef, on native and cultivated pastures. Other research project within this program are dedicated to the study of supplementary feeding, study of the productive and reproductive behavior of both milk and beef animals, and evaluation of methods of using buffalos as a working force.

IV. FSR AT THE "CERRADO" REGION

1. Introduction

There are in Brazil about 1.8 millions of Km2 (180 million of hectares) of "cerrados". The area of this ecosystems represents about 21% of the total area of the country. To promote the agricultural development of this area the Federal Government established a development program, involving activities of research, technical assistance and credit, other than strenghtening the basic infra-structure for supporting agricultural production. Within that prioritary approach, EMBRAPA created the agricultural research center for the "Cerrado" (CPAC). It has been recognized the necessity of occupying and exploiting rationally the central area of the country, not only in terms of expansion of the agricultural frontier, but also as an important factor in the process of national development. Within this framework, the agricultural research is responsible for finding alternatives that, in the short-run, will influence the agricultural performance of the "Cerrado", also making a more competitive agriculture.

The research program for CPAC includes the project named Development of Systems of Production, which is said to be the final objective of this

research center. In a process of synthesis, this project puts together all available technology potencially capable of inluencing the improvement of system of production currently in use, and the development of new systems. This project therefore, is supported by the others projects of the research center as well as in the research results conducted at others national research centers by product.

2. A Theoretical Framework

The experimental technique in agricultural research can be placed along a continuous in which two stages can be clearly distinguished: analysis and syntbesis of the information. The process of analysis is mainly characterized by the conduction of experiments of limited size, in which,hypothesis testing relative to a limited number of factors and to their interactions, is done. Another characteristic is that in this stage, the use of statistical methods is highly efficient, while the use of techniques for economic analysis, is rather inefficient, vis-ã-vis the real world.

The process of synthesis, on the other hand, is located at the other extreme of this continuous and has the characteristic of collecting information at the farm level. There are two possible methodologies for this stage:

1º) The study of prototypes, which uses farms of the region for collecting information, as well as uses farms which management reflects the production system recommended by the research(this corresponds to testing a "technological package" within EMBRAPA's terminology).

2º) Modelling, which uses simulation techniques with the objective of understanding the operation of the system as a whole. In this stage, the use

of statistical methods for hypothesis testing becomes inefficient, given the complexity of the information collected, while the methods for economic analysis become much more efficient.

Consequently, there is an inverse relationship between the statistical an economic analysis with respect to their power of analysis and synthesis. In order to set up a system of production at the farm level, it is necessary to have a considerable amount of information about the farms, as well as integrated research results. Such a system is assessed under the conditions of the farmer, and this gives information, descriptive by nature, about the performance of the components of the system as a whole.

On the other hand, surveying information at the farm level (case studies), in general, is a complex process and demands the application of financial and human resources, most of the time out of the possibilities of a research unit.

Given the necessity of searching for a system in which the elements will also interact, without having the characteristics of a prototype, the CPAC began testing an experimental methodology, which would constitute a "bridge" between the elements of synthesis and analysis. Such a experimental methodology was called "central experiment", name which says more about the fact that it is a nucleous of experimentation at CPAC.

Therefore, the central experiment can be located within the above mentioned continuous, between both processes of synthesis and analysis. It should be looked as an experimental figure that allows a greater relialability for economic analysis and that also will permit the use of statistical

techniques for the analysis of the information.

3. An Experience with Central Experiments

Agricultural research institutions have traditionally generated technologies based on experimental results conducted in plots of small or compact size. Usually, these experiments are designed for testing one or two hypothesis, in the evaluation of one or two variables. Conventional statistical techniques are used for the analysis of data. After the publication of the results or conclusions of each single experiment, the extensionist or the producer, would have to put them together, to form a feasible production system at the farm level. This type of approach to agricultural research will continue to be of great utility. However, in recent years, the need for a research that allows the observation, at a "farm scale", of the interactions of partial results, combined in a continuous management system within the same area, has been demanded.

EMBRAPA's research center for the "Cerrados", is following that methodology. Its research program is based on the integration of traditional type of experiments ("satellite"experiments), with experiments where the effects of the interactions or synthesis are evident (central experiments). The idea for developping central experiments is not new, but the research team at this Center has tried to do a multidisciplinary work with the objective of integrating the experiments of the research program.

Central experiments at CPAC are characterized by:

1º) Because they synthesize the results of the interactions among several technologies;

2º) They are dynamic, in the sense that modifications can be introduced, considering the results of the "satellite" experiments;

3º) Their size allows the economic evaluation;

4º) They were installed and conducted using similar cultural practices to those of the farmers of the region;

5º) Their require the work of a multidisciplinary research team, mainly during the phases of planning and analysis;

6º) Their require a different type of statistical analysis, with emphasis on the effects of the macrodescriptive variables of the system (soil, plant, climate, etc.), and their interactions;

7º) They characterize problems or limitations that cannot be observed in traditional type of experiments. They are, therefore, a valuable instrument for planning and defining priorities within a research institution.

The statistical methodology for describing and analyzing the information obtained in central experiments, can be summarized through the following procedure:

1º) Obtention of data through the use of samples (20 samples for each 5 hectares);

2º) Characterization of the parameters for the group of macrodescriptive variables of the system, through the use of principal components analysis for each group;

3º) Study of the possible interactions of the macrodescriptive variables, using the method of canonical correlation;

4º) Study of the possible interactions within each group, using the method of simple correlation;

5º) Multiple regression analysis for the macrodescriptive variables, with the objective of quantifying their relative importance.

Two central experiments have already been implanted at CPAC:

1º) Experiment 358

With the objective of testing some methods for the "opening" of the "cerrado" for implanting a pasture, a central experiment was established in an area of 80 hectares. Initially, the area was carefully cleaned, and two tons of lime were applied per hectare. In half of the area, 240 kg. of P_2O_5 were used, while on the other half, 120 kg. of P_2O_5 were applied. For the implantation of the pasture, three different treatments were followed:

Treatment 1: Rice during the first two years, rice and pasture in the third year, and pasture in the fourth year;

Treatment 2: Starting directly with pasture since the first year;

Treatment 3: Rice plus pasture in the first year, and pasture in the following years.

There is a fourth treatment which is a sequence of annual crops, that can be considered as intensive agriculture cultivation. It consists on corn

during the first two years, soybeans in the third year, and corn again in the fourth year.

Due to the uncertainty with respect to the methodology for analysis, two replications were installed, but the experience has demonstrated that those replications were not necessary.

Once the pasture is formed, the next step is to evaluate its performance as well as its stability. In the area with pasture formed in the first year, an experiment with animals was conducted, to measure the support of the pasture during the whole year. In the area with 240 kg of P_2O_5, animal loads of 1.9, 2.3, and 2.7 per hectare, with an initial weight of 190 kg, were installed. In the area with 120 kg of P_2O_5, the loads were 1.5, 1.9 and 2.3 animals per hectare. In the average, the weight gain was 300 kg per animal in 130 days. At the moment of this report, a lot of information relative to the pasture and to the multiple regressions of soybeans and rice productions are still under analysis.

2º) Experiment 357

With the objective of studying the influences of different crop sequences, under different levels of fertilization, on the recuperation of the soil of "cerrados", the CPAC is conducting this central experiment. The following crop sequences are under study:

1. Rice during the first two years, and soybeans during the third year, which is a system normally used by farmers;

2. A sequence of rice, soybeans, and corn, in three years, which would represent a more developed system;

3. A sequence of soybeans, corn, and soybeans, in three years, which would represent a systems with a higher technological level.

Three different systems of fertilization were used in this experiment. Two of them are intended to produce a recuperation of the "Cerrado" soils, under different intensities: while one of these systems intends to recuperate the fertility of these soils by the end of the first year, the other one will recuperate the fertility in about four years, after which, both alternatives will be comparable. The third fertilization system will be only for maintenance of the natural fertility.

Many parameters are under study within this central experiment. Among them, the following can be mentioned:

1º) The effects of liming in neutralizing the toxical aluminum and rising the amount of calcium and magnesium to an adequated level, for each of the three levels of fertilization;

2º) The recuperation effects of phosphorus;

3º) Effects on the soil density and on soil texture and structure;

4º) Effects on the density of the root system;

5º) Every other parameter with respect to growing and development of the crops, productivity and profitability.

V. FOR AT OTHER REGIONAL CENTERS

1. Cropping Systems

a. Rice

A diagnostic conducted by EMBRAPA's national research center for rice and beans (CNPAF), indicated the existence of five main problems in the production of rice under dryland conditions in the "cerrados". These problems are related to: hidric deficiency, soil fertility, deseases, pests, and weeds. With the objective of finding solutions for these problems in an integrated manner, experiments were conducted during 1975/76 and 1976/77. Each year two different rice varieties, with and without supplementary irrigation were used on nine different production systems. Several treatments such as: one or two manual weeding (hoeing), different levels of fertilization, treatments for seeds, insecticides, fungicides, herbicides, and compactation of the soil, were used. Through the use of statistical techniques, the isolated and common effects of each treatment were estimated and analyzed. For each of the nine production systems under test there are already available data with respect to the productivity of each variety, with and without supplementary irrigation, and also, data on the profitability of each production system.

b. Beans.

In 1975/76, a comparative study between a consortium system of beans and corn, against single beans, was conducted by the Center with respect to productivity and profitability. For comparison of the two systems, the index of land use efficiency

$$UET = \frac{R_1 \text{ consortiated}}{R_1 \text{ single}} + \frac{R_2 \text{ consortiated}}{R_2 \text{ single}}, \text{ where}$$

R_1 and R_2 correspond, respectively, to the yield per hectare of beans and corn, was used. The following results were obtained:

1º Beans productivity, in Kg/Ha, under consortium, was higher than under single cropping; results for corn were exactly the opposite;

2º Net income in cruzeiros per hectare, under the system of consortium, was greater than under single cropping, for the same level of technology;

3º The index of land use efficiency indicated an advantage of the system under consortium over the single cropping system, for the same technological conditions,

In 1976/77, another study of consortium of beans and corn, including five technological factors, was conducted by the center. Those factors were: distances of corn between rows, soil treatments, fertility, type of seed, and varieties of beans. The results for this research project indicate:

1º Fertilizers were the most important factor for increases in productivity and also they produced the major impacts on profitability;

2º One of the beans varieties showed a greater economic sensitivity to higher technology levels;

3º Treatment of the soil is not economic, due to the high price of this input and to its small effect on productivity.

c. Wheat-Soybeans

The experiment named "Study of Wheat-Soybeans Production

Systems" was initiated in 1975 by EMBRAPA's national research center f wheat (CNPT). Five factors of production are under study in this research project: types of soil preparation, liming, stubbling (crop returns), seedrates, and nitrogeneous fertilization in wheat. The statistical analysis during the first year (1975) for wheat, was possible only for three factors: liming, seedrates and nitrogeneous fertilization. The preliminary results showed, for this crop, a tendency to the use of low amounts of lime and a greater seedrate. During the first year for soybeans (1975/76), the statistical analysis was possible for all five factors of the experiment. The preliminary results indicate that, contrary to wheat results, there was a highly significant difference to liming. There was also a tendency indicating that the better nitrogen level for wheat could cause a small decrease in soybeans productivity. The second year (1976) of experimental results for wheat indicates that no-tillage gave a 14% increase in yield, and the efficiency of nitrogeneous fertilization was excellent (N optimum = 90 Kg of N/Ha). During the second year of soybeans (1976/77), again, liming had a positive effect on yields, and no-tillage also produced a positive impact on productivity. There was no response to seedrates. Again, the highest soybean yield corresponded to the nitrogen level that produced the highest yield on wheat the prior year. During the third year of experimentation with wheat (1977), no-tillage, again, was responsible for a 29% increase in productivity over the conventional system of soil preparation. The optimal economic efficiency in the application of nitrogen was about 70 Kg/Ha. However, the average productivity of nitrogen was low, of about 4,5 Kg of wheat obtained per each Kg of nitrogen, when compared with the 15 to 20 Kg of wheat obtained per Kg of nitrogen in other wheat producing countries. It is important to mention, however, that since these experiments are designed for at least six years, it is evident that all these results and conclusions are preliminary. All these data will need a greater number of years and observations to be analyzed, and also they will probably be studied under other environments.

d. Rubber trees and Others.

EMBRAPA's national research center for rubber trees

(CNPSe), is conducting an experiment under consortium, for a better land use, and for reducing the costs of installing perennial crops. Since it is also important to reduce maintenance costs during the time that rubber trees are not yet in production, the Center is studying the consortium of this perennial crop with other perennial crops of greater precocity. Especifically, the objectives of this experiment are as follows:

1º To study the behavior of the rubber trees in consortium with cocoa, "guaranã", coffee, and pepper;

2º To study the effects of the shadow of the rubber trees on the vegetative development, sanitary aspects, production, and productivity, on other perennial crops;

3º To study the nutritional requirements of those perennial crops under the shadow of the rubber trees;

4º To study the physical and chemical transformation of the soil in the consortium of rubber trees with other perennial crops, in comparison with single crops, brushwood, and native forest;

5º To indicate the most economical system of the rubber trees with other perennial crops.

Evidently, all these experiments are of the long-run type. All their consortia were installed recently, in 1977 and 1978. Their methodology is available.

2. Livestock Sistems

a. Milk Production

The research program for EMBRAPA's national research center for milk production (CNPGL), involves the following dynamic and integrated activities: Field experiments, conduction of a physical model for milk production systems an surveying information about it, surveying of periodical data on private farms, and construction of "symbolic" models of milk production systems and simulation studies.

Through that research program, the Center general objective is to contribute to the development of an adequated methodology for the application of the system approach to agricultural

research, aiming the obtention of more efficient milk production systems. Especifically, the objectives are:

1º To get information for the construction of' qualitative and quantitative models;

2º To identify relevant factors for research with sensitivity in the model;

3º To get the participation of the multidisciplinary research team in the experiment, observing the behavior of a milk production system.

For implanting the physical production system model and choosing the basic technology, the Center took into account some results of research, information from extensionists and farmers, other than from its own researchers experience. The main factors considered for this experiment were:

1º Representation of the basic characteristics more commonly found in the farms of the region;

2º Introduction of some techniques recognized as efficients, when investigated in isolation;

3º Implantation of a technology which requires low capital utilization.

Technical and economical evaluations are under way. To make possible those evaluations, many parameters are being observed, measured, and tested. Among them, one can mention the following: milk production, animals for sale, weight gain, rate of pasture support, availability of pastures, food consumption, birth and death rates, age to the first delivery, costs of production, and input-output relationships.

The periodical data surveying for evaluating current systems of milk production, has the main objective of making possible comparative analysis with the physical model already installed at the Center. It will also make possible the comparison of technical and economic analysis between the two sustems. In collaboration with the extension service, 350 farms, located in several regions, are subject of this monthly survey. For this experiment, as well as the physical procuction system model, there exist already a completely developed methodology and the data of the first year are under analysis.

Finally, a symbolic milk production system model and simulation studies are under way. For building this regional model, involving variables that are common to several systems of the region, the following stages are considered: identification of the components, inputs and outputs of the system; identification of the processes connecting the components: building of a quanlitative structural model of the system; surveying the available information; estimating probable value of those processes in which there is no enough information (research projects); quantifying the model, using the available information and the estimated values; implementing the model within the computer; verifying the model to determine whether its behavior is in accordande with the information used for its construction; validation of the model, to check whether it is representing a good approximation of reality.

After the model validation, its sensitivity will be studied, in terms of the behavior of the variables of performance, when modifications in important parameters on which there is little or no information, are introduced. This methodology will allow the identification of new research projects. The physical model of the Center and the real systems under study (survey), will be of great importance for the validation of the model, Once the model is validated, through modifications in its components, it will be possible to synthesize new systems, always looking for those with higher physical and economical efficiency relative to the current systems.

b. Beef Production.

The system research approach at EMBRAPA's national research center for beef production (CNPGC), is basically the same that CNPGL's approach. The implantation of a physical model within the Center is already planned.

Prior to the implantation, however, the Center wants to be sure about which specific system will be implanted. For this reason, several simulation models have already been built and tested, while others have been suggested, Presently, the Center is analyzing those models, which go from partial to total cycle models and from static to dynamic models, in order to determine which one or what

combination will be installed in the physical model, For the time being, those models have represented a very important tool for defining priorities for specific research projects for the Center.

ANNEX 3

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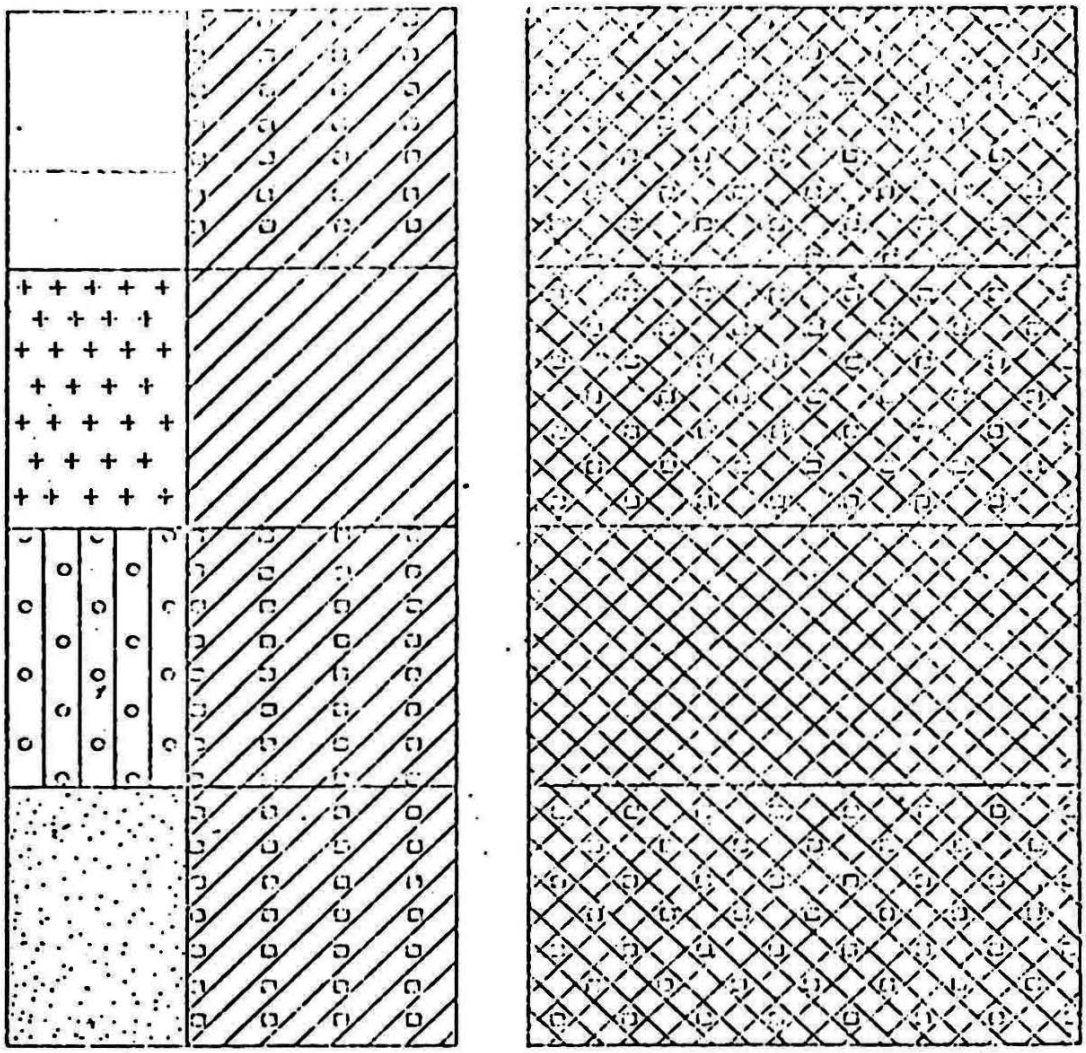
ANNEXES



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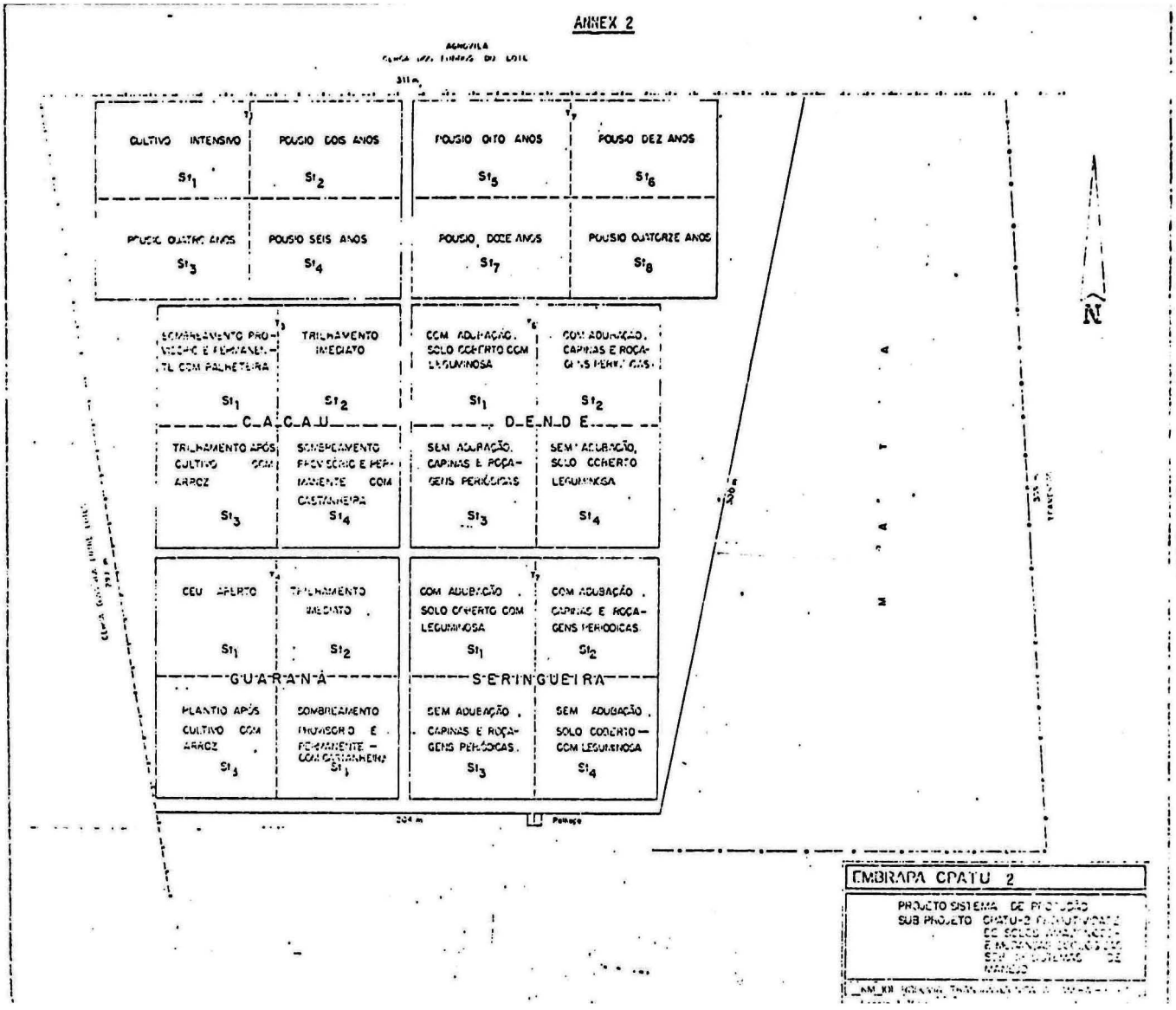

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