REPORT[1]

of a consultancy with the

CENTRO DE PESQUISA AGROPECUARIA DO TROPICO SEMI-ARIDO[2]

(CPATSA)

---

[1] For a summary of conclusions and recommendations see items 13 and 14 of this report.

[2] Prepared by Jacob Kampen, Principal scientist, Land and Water Management, Farming Systems Research Program, ICRISAT, Hyderabad, India.

A REPORT ON A SHORT-TERM CONSULTANCY

ON

SOIL AND WATER MANAGEMENT AND FARMING SYSTEMS

FOR THE

CENTRO DE PESQUISA AGROPECUARIA DO TROPICO SEMI-ARIDO

TO : The Interamerican Institute of Agricultural Sciences

FROM : Jacob Kampen

SUBJECT : Final report

PROJECT : CPATSA (EMBRAPA)

ACTIVITY: Development production systems for dry areas
Soil and water management/Farming systems

OBJECTIVES : (1) To give a series of seminars on:

(a) Farming systems research and technology transfer

(b) Land and water management investigations

(c) On-farm, operational-scale research

(d) Research priority determination

(2) To study the presently ongoing CPATSA research programs at Research Centers and on farms.

(3) To prepare recommendations for the modification of research program components, for the strengthening of the inter-disciplinary character of the work, and for a more effective transfer and diffusion of new technology.

(4) To suggest means for improving the support to, and the linkages with State Research and Extension Organisations.

DUTY PERIOD : April 8 - 23, 1980

DUTY STATION : CPATSA, Petrolina (PE)

INSTITUTION ASSISTED : Centro de Pesquisa Agropecuaria do Tropico Semi-Arido

COOPERATING STAFF :

Name	
Jose Ribamar Pereira	Technical Director
Aderaldo de Sousa Silva	Soil and water management
Arnobio Anselmo de Magelhaes	Soil and water management
Everaldo R. Porto	Modelling/resource management
Otavio Pessoa de Aragoa	Soil and water management

PERSONNEL INTERVIEWED :

Name	Function	Location
C.A.D Oliveira Ventura	Director, I.P.A.	Serra Telhada
Jose Nunes Filho	Soil & water management	" "
L. de Souza Maeedo	Irrigation	" "
Anlonio R. de Souza	Soil conservation	" "
Peter Penic	Pasture management	" "
M. Eunice de Q. Vieira	" "	" "
Jose F. Filho	Technology diff.	" "
Franciso N. Pereira	Farmer	" "
L. Corsino Freire	Economist	Ouricuri
Josias Cavalcanti	Plant protection	"
S.G. de Albuquerque	Animal production	"
Aderaldo S. Silva	Soil, water management	"
Jose S. Silva	Technology diff.	"
Arnobio A. de Magelhaes	Soil, water management	"
Carlos E. Martins	Irrigation	"
L.H. de O. Lopes	Plant protection	"
N.N. de Siqueira	Sertanejo Man.	"
L.P. de Araujo	Farmer	"

Name	Function	Location
Renival Alves de Souza	Director, CPATSA	Petrolina
Manuel Abilio de Quaeroz	Technical Director	"
Francisco Jose A.F. Tavore	Res. Coord.EPACE	"
Aldo Arnaldo de Medcires	Researcher EMBR	"
Fidelfo Tavores de Sa	Tech. Diff.EPACE	"
Helio Almeida Burity	Prod. Syst.IPA	"
Soaa Felinho dos Santos	Soil Cons.EMEPA	"
Luiz B. Morgado	Soil Fertility CPATSA	"
Manuel Xavier dos Santos	Plant breeding CPATSA	"
Marcos Antonio Drumonel	Forestry CPATSA	"
Martiniano C. De Oliveira	Pasture mans.CPATSA	"

SEMINAR PARTICIPANTS :

Name	Function	Location/Org
Antonio Gones de Aranjo	Agronomist	UEPAE, Teresina
Pierre Michel Saint Chair	Consultant	CPATSA, IICA
Aldo Arneldo de Modires	Researcher	UEPAE, Cuiro
Helio Almeida Burity	Researcher	IPA, Seura Telhada
Everaldo R. Porto	Researcher	CPATSA
Oelavio P. Aragoa	Researcher/Coord.	CPATSA
Francisco J.A.F. Tavora	Researcher	EPACE
Harbans Lal	Consultant	CPATSA, IICA
Joao Felinko dos Sanlos	Researcher	EMEPA
Ian Beale	Consultant	CPATSA, IICA
Filadelfo Tavores de Sa	Techn. Diff.	EPACE
M.M. Choudry	Researcher	CPATSA
Orlando M. De C. Filho	Researcher	CPATSA
Marcus Antonio Drumond	Researcher	CPATSA
Martiniano C. Oliocira	Researcher	CPATSA
Aderaldo de Souza Silva	Soil, Water Man.	CPATSA
Jose de Souza Silva	Tech diff.	CPATSA
Luiz Balbino Morgado	Soil Fert.	CPATSA
Eduardo Assis Menezes	Plant breeding	CPATSA
Jose Ribamar Pereira	Soil fertility	CPATSA
Renival A. de Souza	Director	CPATSA

Name	Function	Location/Org
Eliane Mogueire Choudhury	Soil physics	CPATSA
Jose P. De Aravio	Soil Fertility	CPATSA
Clementino M.B. De Faria	Soil Fertility	CPATSA
Josias Cavalcanti	Agronomist	CPATSA
Soao Felinko dos Santos	Soil conservation	EMEPA
Everaldo de V. Bandera	Tech Diff.	SUDENE
Luiz Corsino Freire	Economist	CPATSA
Iose Nunes Filho	Soil, water man.	IPA
Mauricio Bernardes Coelho	Irrigation	CPATSA
Carlos E. Martins	Plant nutrition	CPATSA
Elias Oliveira Filho	Agronomist	EPABA- Irece
Jose Maria Meira Lessa	Soil, water man.	EPABA - Irece
Walter Brandao	Tech. Diff.	SUDENE
Moaeir Alves da Silva	Irrigation	CPATSA
Arnobio Anselmo de Magelhaes	Soil, water man.	CPATSA
Paulo Sergio de S. Magelhaes	Hydrology	CPATSA
Gilberto José de Moraes	Entomology	CPATSA
Gilberto Gomes Cordeiro	Soil salinity	CPATSA
Valderi Vieira da Silva	Tech. Diff.	UEPAE, Teresina
Manuel Xavier dos Santos	Plant breeding	CPATSA
Luiz Carlos Galindo Bairos	Tech. Diff.	UEPAE
Marias A De Oliveira Malos	Tech. Diff.	UEPAE

ACTIVITIES DEVELOPED:

(a) Prepared and presented several seminars on farming systems research and natural resource development and management (for details see Results of activities)

(b) Studied and discussed with CPATSA scientists research results of previous years and means to improve experimentation and analysis (for details see Results of activities)

(c) Proposed several new experiments in the areas of agronomy, soil fertility and soil and water management (for details see Results of activities).

(d) To further improve the support of and the linkages with State Organisations, suggested the setting up of small task forces and the identification of personnel with specific responsibility for different phases of research especially the operational-scale and on-farm studies.

(e) Identified lacunae in ongoing research programs that make it difficult to attain early results and means to strengthen the research and extension oriented programs.

RESULTS OF ACTIVITIES:

After arrival at Recife on April 10, brief visits were made to on-farm research projects at Serra Telhada and Ouricuri. Work at the Caatinga research station near Petrolina involving cropping systems, forestry and range management was inspected on April 14 and 16; some irrigation experiments at the Bedebouro site were also seen. A seminar was prepared and presented on April 17. On-farm irrigation development activities near the Sobradinho lake were visited on April 18. A draft report was submitted to the CPATSA Administration and briefly discussed.

(a) The Seminar;

(a.1) Determination of research priorities - Evidence from ICRISAT

Based on in-depth analysis of research in farming systems and economics, conducted at ICRISAT during the last 8 years, a set of generalizations has been derived. It is believed that such generalisations, once fully tested, are useful for several purposes:

- They lead to further researchable questions and sharpened hypotheses for new enquiries. They may serve similar purposes in the research planning stage at regional research centers, particularly when scientists engage in new research fields.

- They may assist scientists at regional and at coordinating research centers in interpreting a variety of research results on a comparative basis across locations.

- Once the geographical limits to the generalizations are known, they can become useful to implementation and development funding agencies at the project identification level and possibly in actual planning.

In the past, farming systems research has focussed on : Assembly and interpretation of existing base line data; The communication of basic and applied research results; Basic or supportive research on methodologies; Simulation or systems analytic studies; The organisation of inter-regional cooperative trials and research networks; The training of researchers, and; The development of appropriate farming systems at selected, representative locations.

Past research results lead to suggestions for farming systems in alternative regions that are of a striking location - specificness. Thus, there is a further need for comparative evaluation of research results derived elsewhere; for the early analysis and publication of research results from resource management research; for research that will further improve simple simulation models to be used for deriving long-term probabilities; for using models to test alternative hypotheses and to determine research priorities; for the production of "iso-technology" maps for various production techniques; for the initiation of multilocation "omnibus" experiments where uniform data sets are collected; for a greater research effort into cooperative research programs at research centers and on farms, and; for an increased emphasis on considering farming systems as consisting of components to be assembled differently for distinct regions according to their profitabilities, costs and local preferences.

In the discussion it was pointed out that for ICRISAT - as for CPATSA - it is important to be able to select research priorities on the basis of the potential returns envisaged. This is particularly true at a time when financial resources for agricultural research become more limited. Such annual updates of direction and orientation of research programs is feasible only if the compilation, analysis and publication of the collected data is done in time, well ahead of the subsequent planting season. Although this may be difficult to achieve, research planning is not feasible without it. At ICRISAT, the results of past research analysis have much increased the emphasis towards operational-scale and on-farm research. However, for CPATSA and the State Research Institutions there appears to be a continuing need for further strengthening of component research.

In addition to supplemental irrigation from collected runoff or groundwater, there are several other avenues to reduce the undependability of rainfed agriculture. Examples are intercropping systems, use of chemical fertilizers, improved crop management, weed control, etc. Partly because of the extreme unreliability of the rainfall at the present CPATSA Caatinga research site, supplemental,"life saving" irrigation work may have been overemphasized. It is important to also explore other potential possibilities to improve and stabilize completely rainfed agriculture in these regions for those farmers without acces to water.

In research on rainfed farming, it is important to realise that two major questions must be answered:

- A clear answer must be obtained to "what" is to be done to improve the crop growth environment and to maintain productivity.

- The knowledge gained must be translated into "how" this new information is to be fitted into existing farming systems. Such problem-solving, applied investigations are most effectively executed by farming systems studies on an operational scale at research stations and on farms.

Although the pressure may often be great to start early on integrating technology component into technically and economically viable systems, one must know the quantitative effects of components manipulation in different environments - and different years - before one can effectively integrate and synthesize farming systems.

(a.2) Farming systems research and technology transfer

ICRISAT's Farming Systems Research Program attempts to contribute to raising the quality of life in the Semi-Arid Tropics through interdisciplinary and cooperative efforts to improve the use of natural, human and capital resources. It has been found that dry sowing on clayey soils is successful if the early rains are dependable; introduction of toolcarriers results in greater timeliness and improved efficiency of cultural operations; the broadbed-and-furrow system controls excess water and facilitates tillage;

intercropping increases total yields substantially on Vertisols and Alfisols; effective weed control can be attained through the integration of mechanical, biological, and chemical means.

Watershed-based resource development and management contributes to increased and more stable yields; the combined effect of different production factors applied together far exceeds the total effect of these factors applied singly; and improved farming systems tested in operational-scale research watersheds consistently result in three to five fold increases in rainfall productivities. On-farm studies to involve farmers in appropriate technology development and to search for effective forms of group action have begun.

In discussing some research results in more detail considerable attention was paid to improving the "steps in technology" experimentation. Although in 1978 - at Philadelfia - the coefficients of variation (C.V) were relatively small, the differences between entirely "traditional" and fully "improved" technology was only about 30 percent. Extreme variability in the research sites at the present Caatinga location has during the last two years resulted in such high CV's that no statistically significant differences can be derived. Additionally, the difficulties encountered are considered due to:

- Insufficient available information on the individual technology components.
- Plot sises too small for an economic analysis (only 36 m^2 where a minimum suggested size might be 150 m^2)
- The moisture regime of the individual research plots is not independent and separation of plots by small drains is required.

It was generally agreed that there is an urgent need to increase the research on sorghum and other more drought tolerant crops such as cassava to arrive at more stable systems of farming under entirely rainfed conditions. Although the dependency of the present Caatinga research site upon the availability of supplemental irrigation is realised, initiation of work at a second site under more dependable rainfall conditions is not judged feasible. The need for more work on system modelling to predict the long term probabilities of results attained during only a few years of experiments was emphasized. Possibilities for cooperative work with ICRISAT's Agroclimatology subprogram in multilocation experiments may be explored.

(a.3) Land and water management investigations

Frequent shortfalls in food production and a deterioration of the productive capacity of the resource base have become common in many areas of the Semi-Arid Tropics. Watershed-based natural resource development which involves the optimum use of the watershed precipitation through improved water, soil, and crop management has the potential to contribute significantly to greater productivity and resource conservation. The development of improved watershed management technology, adapted to what farmers require, is a complex and long-term task; all land uses, including grasslands and forests must be considered. To attain successful agricultural development approaches, the responsibility of a coordinating Institute consists of the generation of improved research methods, cooperative investigations focussed on operational-scale research and the integration of new technology, and training programs.

In ICRISAT's Land and Water Management research program, one can distinguish between four major activities:

- Evaluation of the in situ yield effects of soil and water use and conservation practices that are presently common
- Investigations of approaches towards improved soil and water management resulting in higher and more stable production.
- Studies on small-scale, supplemental irrigation of upland crops to decrease the risk involved in rainfed agriculture.
- Research on real farms towards implementation methods and effective forms of group action for new systems of farming.

It is important to realise that farmers in the Semi-Arid Tropics have traditionally obtained their livelihood through primitive rainfed agriculture and livestock grazing. Improvement of this situation will often require very considerable investments and change because the strategy must be to utilise development projects to provide the social and economic basis for conservation programs. Once farmers have a productive resource in hand they will conserve this resource to the best of their ability. Thousands of farmers in the Semi-Arid Tropics are poor because of their poor resources and if one provides them with a poor technology as well, they simply will remain poor.

In the discussion, it was illustrated that the graded broadbed system of cultivation has great flexibility in adapting to the widely different row spacings of sole and intercrops. Also, it must be realised that as long as the optimum range of per hectare populations is maintained, considerable freedom exists in selecting suitable inter-and intra-row spacings.

The local importance of groundwater as a source for supplemental water was emphasised. Runoff water collection and storage on a small scale may often be a relatively expensive measure and therefore all other available options - including in situ water conservation in the soil profile - should be explored first. However, potentials for improvement must also be explored for those farmers located in the upstream portions of catchments, on the shallow soils. Shifting attention to groundwater or larger scale water collection means a move down the toposequences. The question must always be asked if all possible options to improve the productivity of the natural resource base in the upland areas have been exhausted. One may sometimes have to consider economics of survival rather than to recognise only direct benefits.

Finally, where "bad", "medium" and "good" rainfall years occur at random, one can ask on which type of moisture environment the research should focus. It was agreed that in the medium and high rainfall regions where moisture on average is somewhat more dependable, one should be able to "harvest the good years". Therefore, in these regions one would aim at developing a technology that enables one to gain high yields in the years of reasonably high and well distributed rainfall. To facilitate the implementation of such farming systems credit must be available on flexible terms such that the initial risk becomes acceptable. In the drier semi-arid regions where the main component of the farming systems is based on range management and animals, stability is an important goal. One may therefore aim at developing land management and cropping systems that will yield food crops for subsistence even under adverse conditions.

(a.4) On-farm, operational-scale research

The objectives and scope of the cooperative on-farm research in which ICRISAT together with National Organisations participates, are:

- To find ways for farmers to participate in the technology development process
- To examine the need and feasibility of group action for adoption of watershed-based systems of resource development and management
- To adapt, test and measure the performance of prospective land and water management and crop production technologies on farmers' fields.

Two committees have been initiated to guide implementation of the on-farm research projects:

- An overall Advisory Committee - Technical (ACT). The ACT designs the research projects, provides technical opinions and information to farmers and is responsible for developing policy guidelines.

- An Advisory Committee - Local (ACL) has been constituted each village. This Committee is concerned with the selection and actual implementation of the development activities; it ascertains that the alternatives suggested by the ACT take due account of local preferences and conditions. The final decision-maker on all aspects of development plans and improved cropping systems is the concerned farmer.

There may well be a need for two "levels" of on-farm experimentation: (1) A technology component evaluation in replicated trials on the basis of precise measurements; and (2) watershed-based or other operational-scale comparisons aimed at technology integration and farmer involvement but with somewhat less exact measurements. Because farmers may frequently not be interested in participating in the first phase - and also because they should, at this stage, not be exposed to the risks involved in experimenting with new technology - it may be necessary to rent land on farms for this purpose.

Finally, for successful on-farm research, executive responsibility needs to be clearly defined. Although interdisciplinary teams must back up the on-farm research, one or two scientists and technicians need to be charged with day to day implementation.

In the discussion, the need for detailed data on all development costs, inputs and produce values to facilitate an economic analysis of the net returns to the new technology was emphasized. To accurately determine yields, it is necessary to collect at least 16 samples (of 10 m^2 each) per hectare under conditions of reasonable uniformity. During the first few years of on-farm experimentation, particularly if the soils are heterogeneous, it is advisable to collect yield information both on the basis of samples and by determining the total bulk yields. This procedure facilitates the determination of harvest and threshing losses as well as estimates of sampling errors. Adequate technology component knowledge is essential for successful on-farm research; to be convincing the yield gains of the new technology must be impressive. The selection of farmers for participation in ICRISAT - coordinated studies is done on the basis of identifying a suitable small watershed. There is often a wide diversity between small-scale and larger farmers involved. Recent experience shows that the smallest farmers are often the last to try the new technologies.

For a farmer, the most economical technique will always be the most attractive. Researchers however, may consider other aspects including social ones in their priority determination. Under some conditions this may lead to a focus on more labor-intensive technologies rather than those that could result in labor displacement. Choices with regard to relative emphasis on high risk versus more dependable rainfall areas must be made by the government organisations responsible for research policy decisions; scientists' incentives must be set accordingly. Although national production and food supplies may be more rapidly increased by research serving high rainfall regions, considerations in favor of equity may lead to more work in the regions with the poorest resource endowments. Unpredictable needs for sudden massive relief programs are another reason to search for long-term solutions in the latter areas.

Although ICRISAT started its involvement in cooperative on-farm research only two years ago, there have already been substantial benefits from the participation of farmers in the development of new technology. Examples are the adaptation of animal-drawn equipment to more appropriately serve local requirements and to decrease costs, the adaptation of implementation methods for new land development and water management techniques,

and the generation of intercrop system combinations adapted to regional preferences.

(b) Recommendations and Observations :

(b.1) The present program

First of all, it is appropriate to commend the scientific staff of CPATSA with the indeed impressive progress that has been made during the last few years in creating a viable research program. Three major areas of activity can presently be distinguished: The compilation and study of base line data; Investigations at Research Centers, and; On-farm studies aimed at technology adaptation and implementation. Also, effective links now exist with action and development agencies oriented towards technology extension and diffusion. The confidence gained in the effectiveness of the research programs can be gauged for example from the participation of CNPQ, SUDENE and SERTANEJO in more basic and applied research projects.

The strength that the program has attained is also evident from the enthusiasm and understanding of the researchers and administrators, and from the quality of the work carried out at research centers. Probably even more important, effective interdisciplinary teams have been created for investigations of a holistic and integrated character, on an operational scale at research stations and on farms. EMBRAPA may consider itself fortunate, that so much has been achieved in such a short time often with temporary facilities.

However, as all that truly know semi-arid agriculture know, the task of improving the existing farming systems is complex because the target farmer is mostly poor and has few resources. It takes time to create scientific teams that can independently and objectively decide upon research priorities given broad guidelines. The required diversity with regard to disciplinary background in many of the State Enterprises, particularly in the areas of forestry, annual husbandry and range management has not yet been attained. Additional strengthening of the CPATSA team at Petrolina, e.g. in the areas of crop improvement, soil physics and agricultural tools and equipment is needed. Thus, much remains to be done.

In the following paragraphs, some tentative observations, guidelines and recommendations have been spelled out. It is important to realise that these suggestions are based on a brief visit and therefore will need further study; they are not prescriptions. Given the specific characteristics and needs of each area in the Semi-Arid Tropics, few "handbook" - type solutions can be expected to evolve. Although the principles involved in attaining superior cropping systems and improved natural resource development and use may be clear, the ultimate task of finding appropriate, site-specific solutions for the special problems encountered in a given area will remain the responsibility of local researchers, technicians, extension agents, and finally, farmers. Particularly in N.E. Brazil, the vital importance of forestry and animal production in existing farming systems must be realised and capitalised upon.

To fulfill their responsibilities effectively, those charged with agricultural development will have to acquire the ability to invent the most suitable solutions to each particular situation rather than applying a given set of rules. Thus, less emphasis must be placed on testing techniques found successful elsewhere and more on developing new solutions to the real problems of local resource environments. Also, strong training programs will be required aimed at increasing understanding of the limitations, constraints and potentials of present farming systems and the requirements of improved production technologies as well as their application. Fortunately, a beginning is being made to meet these new challenges.

(b.2) Research site heterogeneity

A serious problem observed at all research sites is the extreme variability of the soils in terms of natural fertility and depth. Although this might be expected on farms, its occurrence-at this level - on research station land is alarming. The result is that different replicates of the same treatment produce very unequal yields. For example, with CV values of 40 percent observed in an experiment with different quantities of chemical fertilizers on the Caatinga site in 1979,there is little use in further analysis. The variability in results is especially evident at low fertility levels and greatly limits useful research opportunities to determine optimum farming systems components.

To alleviate this limitation, an effort should be made to identify - or to create - more homogeneous areas by growing uniformly fertilised sole crops on major portions of research station land during one or more years. If new land were developed, precautions should be taken during the clearing process to gain greater homogeneity. This might be attained by removing trees, branches and other materials to windrows rather than burning these at random.

(b.3) Land and water development and management

Research on the improved use of natural resources and land and water development are important because good land is limited. The generation of more effective, less costly land clearing methods is urgent because these costs have quadrupled during the last few years (now approximately 20.000 cruzeiros per hectare)

Studies on improved land and water use at CPATSA distinguish between the requirements of the 600-800 mm and the 400-600 mm average annual rainfall zones. Work is presently carried out on five different aspects:

- One finds over 70.000 small runoff reservoirs in the Northeast. The water is primarily used for domestic and animal use; there is little irrigation. CPATSA scientists are involved in trying to develop viable production techniques along the boundaries of the reservoir following the receeding water in the dry season. Approaches towards more efficient water use on the upland crops in the areas below the dam, using reservoir water to backstop rainy season cropping would seem to have substantial potential; low low pressure plastic pipes might be tried for water conveyance. In reservoirs with large areas of shallow water, compartmentalised reservoirs must be tested.

- Primarily in the 600-800 mm rainfall zone 'watershed-based' farming systems are being tried. In these rather intensively farmed areas, runoff water is collected from cultivated land in small (2000 - 6000 m^3) reservoirs. At times of drought, the collected water is recycled to supplementally irrigate the crop in the watershed. Evidence from ICRISAT appears to indicate that this approach may be most successful with rather high value crops such as fruits and vegetables. Also, whenever there is a choice between existing reservoirs and new small runoff collection facilities, the former may be economically more efficient. There is an urgent need to further study the economics of watershed-based farming systems. Also, in this agroclimatic region, studies of soil and/or organic mulches to conserve moisture may be useful.

- "Runoff" farming systems are investigated primarily in the 400 - 600 mm average rainfall zone. In these less intensively farmed regions the contributing catchment is different from the receiving cultivated area where crops like maize and beans are grown. Recharge of the soil profile in the cultivated area may be either direct or after temporary storage in a small dug reservoir or pond. In these regions, the appropriate farming systems envisaged are based primarily on livestock grazing and forestry; only a relatively small portion of the total farmed area is allocated to subsistence food crops. In this agroclimatic zone, a greater emphasis on research of effective in situ water conservation methods such as tied ridges and graded cultivation is required.
- Studies on the optimum use of water resources encompass water conveyance, application methods, desatinisation and water collection from rooftops or rocky surfaces for human consumption. Innovative adaptations of drip irrigation systems - based on porous clay pots - may be of potential use for high value crops. Their economic application in food crop cultivation would seem doubtful.
- Investigations of drought tolerant crops and cropping systems.

(b.4) Steps in technology and operational-scale research

A basic hypothesis in these types of studies is that the components of the system that one is trying to integrate are indeed understood. Unfortunately, this in some situations does not appear to be the case and it is therefore difficult to synthesize the system. This is evident from several examples such as the yellowing of maize leaves - sign of N deficiency - in "optimum" technology treatments with supplemental irrigation; the planting of several maize or sorghum seeds at one spot in the plant row without thinning which is common practice in existing technology, applied in the improved treatments, and; the planting of three maize rows of 50 cm apart rather than two rows at 75 cm which is more effective under supplemental irrigation; "Optimum" technology is presumably different at alternative moisture levels. Thus, one gains the impression that the "optimum" or "improved" system technology is not yet fully known and that operational-scale, steps in technology, and on-farm research is ahead of the available knowledge on system components. This should not be and therefore a reemphasis on component research in fertility and crop management research is called for. Given the available scientific manpower resources and the facilities of the Caatinga research site, this would seem feasible without decreasing the involvement in other phases of research.

Some additional questions and comments can be made with regard to the research at the Caatinga site near Petrolina. Because of the magnitude of the advective energy component, a short vegetative cover in the weather station area would seem more appropriate than the present bare surface. The hydrologic measurement structures - in watershed based research - are rather elaborate and may be too costly to be repeated at many other locations. The water balances of small tanks can be more accurately determined by placing a normal U.S. Weather Bureau Class A evaporation pan in the water, surrounded by a metal stilling well. Accurate daily readings can then be obtained of reservoir evaporation and (evaporation and seepage) from another reservoir connected stilling well. With regard to water conveyance for supplemental water in small systems, the potential use of cheap, flexible, low pressure plastic pipes may be investigated. Some evidence was observed in the "technology steps" experimentation pointing to potential rewards of tied furrow systems; this needs further research.

Finally, at the present Caatinga research site, it has been feasible to conduct research only through the use of supplemental irrigation. Rainfed crops in the past two years died or yielded very little. Many farmers in the Northeast have no access to supplemental water and the potential improvements in entirely rainfed situations must also be investigated. To facilitate this, a research site under somewhat more dependable rainfall conditions may well be required.

(b.5) On-farm research

Two sites of on-farm research were visited (Serra Telhada and Ouricuri). At Serra Telhada, a runoff farming systems has been laid out with a water collection area - to be grassed -, a small reservoir (3500 m^3) and a separate cropped area below the pond that will be supplied by gravity flow. Although the visit was made in the middle of the rainy season, the maize and beans subsistence crops had only just been planted. The probability of sufficient water for crops to mature was judged low. A graded broadbed-and-furrow system had been implemented using labor. However, essential land smoothing had been deleted and land clearing was only partially complete. Little chemical fertilizer was applied even in the area to be supplementally irrigated.

In the on-farm experiments at Ouricuri the maize was near heading stage and the beans nearly mature. Compared to the crops in nearby fields, the experimental area was late sown. Crops in the research watershed were extremely disuniform presumably due to heterogeneity in soil fertility and a relatively low level of chemical fertilizer applied (only 40 kg N/ha). Symptoms of Zinc and Phosphorus deficiency were frequently observed. The final yields of the on-farm experiment were estimated only slightly higher than the normal yields with existing traditional technology. Rainfall had been scanty and two supplemental irrigations had been applied, however little difference in crop appearance compared to entirely rainfed crops was evident. The farmer when asked what he would do if the support involved in the study were withdrawn responded that he would have to return to traditional technology because of the high labor requirements of the new system.

An important benefit of the on-farm research consists of the feedback that can be provided for research consists of the feedback that can be provided for research program direction. Observations and comments that may contribute to improving the quality and effectiveness of the on-farm activities are:

- One must be clear with regard to the optimum or improved levels of the system components (e.g. variety, population, cropping system, fertility, soil management, moisture regime, etc) before one can expect to successfully demonstrate the superior performance of the entire system of farming. Thus, it may again be suggested that more emphasis be placed on component research both at the Research Centers (CPATSA and the State Enterprises) and where required also on farms.
- Responsibility for the conduct of these experiments must be clearly assigned not just to "an interdisciplinary team" at CPATSA and the State Research Centers but to one or two scientists. These "coordinators" should visit the experiments regularly, in the growing season at least once a week. A committee similar to the ACT (see seminar) may be set up.
- At the locations of on-farm research, a qualified technician must be incharge of the day to day execution of the project. Continuous involvement of the farmer should be maintained in order to ensure that the improved systems of farming are relevant to his situation. The on-farm technicians will require mobility to ensure timeliness of operations.

It is of critical importance that the demonstrated improved systems of farming are indeed clearly more profitable than those feasible with existing technology. Small gains of less than 50 percent will not capture the imagination of farmers and widespread implementation will be impeded.

(b.6) Linkages

Several types of linkages can be considered: those between disciplines at CPATSA, those between CPATSA scientists and the on-farm research, and relations between CPATSA as a coordinating agency and the State Research and Extension Enterprises. It is suggested that to enhance the interdisciplinary character of the research projects at CPATSA one or two "omnibus" type experiments be designed. In such experiments several scientists work together to attain one common goal (e.g. gaining information on the optimum fertility management levels, population densities and row arrangements of intercrops under supplemental irrigation. With regard to on-farm research, the setting up of special task forces to solve specific problems (e.g. micronutrient deficiencies) may improve participation.

A commendable beginning has been made in establishing cooperative research and outreach links with the research and extension programs of the Northeastern States. However, nine states and several research organisations are involved (some such as EMAPA, EPACE, EMEPA, IPA and EPABA are State Enterprises, others such as the UEPAE's are directly linked with EMBRAPA). It is therefore difficult to rapidly evolve the organisational frameworks and to identify and train the associated research staff in holistic farming systems research aimed at the early implementation of new technology. In 1979 the establishment of interdisciplinary teams at one of the research centers in each of the states was accomplished. CPATSA has identified its own farming systems team to interact with and train the State research personnel. These research teams need to frequently discuss the types of operational-scale and on-farm research that can be initiated in the different regions to support agricultural development projects.

To ensure more effective and productive interaction, it is suggested that regular workshops be held by the participating scientists before and after the growing season. Experimental plans and layouts as well as CPATSA coordinated multilocation experiments to study the stability of improved technology across environments could be proposed and discussed at the planning workshop. Data analysis and research results would be reviewed

at the post-growing season conference. Where required, outside consultants might be invited to these meetings to advise on problems encountered in research planning,execution and analysis.

It is realised that it may be difficult for the coordinating scientists at CPATSA to visit all research sites on a regular basis. However, an effort should be made to select one or two especially representative and potentially important locations where CPATSA scientists are fully involved in the experimental program as it relates to systems research.

Grazing animals and forestry are critically important in present farming systems of the region. Few of the State Enterprises will be able to mount effective research programs in animal husbandry, forestry, horticulture, range management,etc. These scientific areas are nevertheless essential to improved mixed farming systems. CPATSA is acquiring special expertise in these subjects and can therefore provide an important service to the State Programs. This is especially valuable given the promising results (e.g. with buffalo grass and eucalyptus trees) of the investigations at CPATSA's Caatinga site.

Finally, upgrading of CPATSA's training facilities (short term informal and longer term in-service) will contribute to improved linkages between the research groups involved in studies on improved, more productive and stable farming systems for Northeast Brazil.

CONCLUSIONS

- Commendable progress has been made by CPATSA in building a viable and effective research structure for dryland areas in Northeast Brazil.
- For CPATSA at Petrolina, further strengthening of the program in the areas of Plant Breeding, Physiology, Environmental Physics and Agricultural Implements appears desirable.
- The State Research and Extension Organisations associated with CPATSA seem to have inadequate expertise in Animal Production, Range Management, Forestry and Land and Water Development and Management.
- The State Enterprises and Research Units require substantial additional development through staffing and training because they have to ultimately evolve the site-specific solutions for agricultural development .

- CPATSA presently seems to be inadequately equipped to satisfactorily perform its essential training function; professional staff and funds will be required.

- Linkages between disciplines within CPATSA and between these and the state organisations can be significantly improved through the setting up of task forces, the initiation of "omnibus" experiments and the organisation of regular workshops for research program planning and data analysis.

- The demonstrations in on-farm research must result in atleast double the yield of traditional technology in an average year in order to capture the imagination of farmers. This can be attained by high quality component research.

- It appears that the number and diversity of research projects carried out at the CPATSA Caatinga site is rather limited given the number of scientists and the available opportunities at the research site.

- The stage has been reached where several scientists together should evolve research priorities and conduct applied and meaningful interdisciplinary projects to attain the set objectives.

SUGGESTIONS AND TECHNICAL RECOMMENDATIONS

- It is evident from operational-scale research that substantial strengthening of component research under supplementally irrigated and rainfed conditions is required in particular in the areas of crop and fertility management.

- To improve the stability of new farming systems, research on sorghum, cassava and other drought tolerant crops needs to be increased.

- For meaningful "steps in technology" research, substantially larger ($\geq$150 m^2) and independent plots are required : component knowledge needs to be improved.

- The present research program at the CPATSA Caatinga site is almost entirely dependent on the availability of supplemental irrigation; a greater research focus on potential improvements under entirely rainfed conditions seems desirable.

- Increased capability in modelling and simulation appears a prerequisite to predict the long term probabilities of a given research outcome in these extremely erratic environments.

- The initiation of coordinated, multilocation research projects is another approach to gain time in reaching dependable conclusions and the State research teams seen capable of participating in such cooperative research.

- For effective research planning, coordination and reorientation, the data analysis and reporting must be complete before the initiation of experiments in a subsequent season

- Research is required to develop low-cost, non-destructive land clearing methods, particularly in areas with supplemental irrigation potential

- A more successful on-farm research phase can be attained by the assignment of specific executive responsibility to a small team of scientists and the involvement of quality technical staff

- A greater effort on in situ soil and moisture conservation methods is required in the low rainfall zone. "Tied" furrows might well be effective in providing improved water infiltration on the deeper soils.

- The large numbers of small reservoirs represent one of the great potential resources of the Northeast. Research to develop effective and efficient water distribution and utilisation systems in downstream areas should be of great priority. For shallow reservoirs, compartmentalisation may be investigated to reduce evaporation.

- An increased effort (both in terms of research project planning and in execution) is required to gain at least some insight in the economics of potential new technologies.

- All feasible precautions must be taken to attain more homogeneous research sites. This can be done through appropriate clearing procedures and the growing of medium fertility cover crops to identify uniform areas.

OCCURRANCES OR FACTS THAT COULD HAVE AFFECTED PERFORMANCE

The objectives and specific job description relating to this consultancy were insufficiently clear before arrival at Petrolina. An exchange of views and the identification of specific problems for attention between the organization requesting the consultancy (in this case CPATSA) and the selected consultant is desirable.

Notwithstanding early written and cabled notification of IICA, indicating the need for a flexible travel itinerary with the appropriate charges for economy class air travel directly related to this consultancy, the required authorisations were received only hours before the scheduled departure time. If and when, in the future, consultants from ICRISAT are involved, by far the most convenient procedure would be to authorise ICRISAT to purchase the required ticket and to charge to IICA the appropriate economy fare.

PETROLINA APRIL 1980