REPORT

APRIL 21, 1987

DESIGN TEAM REPORT

ON

INTEGRATED NUTRIENT SUPPLY AND MANAGEMENT

MARCH 19 - APRIL 15, 1987

Agricultural Research Project (386-0470)

Delivery Order No.23

Contract No.386-0000-C-00-5039-00

WINROCK INTERNATIONAL
1611 North Kent St.
Arlington, VA 22209

SUBPROJECT DRAFT

INTERGRATED NUTRIENT SUPPLY AND MANAGEMENT

I N S A M

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April 24, 1987

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ACRONYMS

ADO	Additional District Officer
AEO	Agricultural Extension Officer
APAU	Andhra Pradesh Agriculture University
CRIDA	Central Research Institute for Dryland Agriculture
CRRI	Central Rice Research Institute
CSSRI	Central Soil Salinity Research Institute
DAO	District Agriculture Officer
FAI	Fertilizer Association of India
GPPUAT	G.B. Pant University of Agriculture & Technology-Pantnagar
HAU	Haryana Agriculture University
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IISS	Indian Institute of Soil Science
INSAM	Integrated Nutrient Supply And Management
INSFFER	International Network on Soil Fertility and Fertilizer Evaluation for Rice
NARP	National Agricultural Research Project
OUAT	Orissa University of Agriculture and Technology
PRII	Potash Research Institute of India
RAU	Rajendra Agricultural University-PUSA, Bihar
RCA	Research Command Area
SMS	Subject Matter Specialist
TNAU	Tamil Nadu Agricultural University
UAS	University of Agricultural Sciences-Bangalore
USAID	U.S. Agency for International Development
VLW	Village Level Worker

I. EXECUTIVE SUMMARY

A. Introduction.

The adoption of new technology and the expansion of lands planted to food crops over the past two decades has enabled India to reach the level of self-sufficiency in food grain production. By the year 2000 A.D., population is expected to increase from the present 850 million to one billion, and food grain demands from 185 million metric tons up to 225 million metric tons. Parallel requirements for wood as fuel and construction, fodder for milk animals to supply the rapidly increasing demand, and the need to adopt ecologically sound farming and land management practices requires that new production practices be undertaken. To fulill these needs will require increased productivity from the better arable lands through higher yields, more intensive cropping systems and the diversion of those lands less suitable from food crops to agro-forestry type systems. The land resources are finite and must be properly managed to meet the increasing demands for food, fuel, fiber and feed production.

B. Justification.

Fertilizer consumption in India has increased from 1.32 million metric tons of N, P and K in 1967-68 up to 7.15 million metric tons in 1985-86. The estimated needs by the year 2000 A.D. are expected to be 14-16 million metric tons of N, P and K. India is not self-sufficient in the production of these primary nutrients.

Most nitrogen feed stocks are either imported or from more costly indigenous raw materials. Indigenous phosphate sources are not high grade and all potassium must be imported.

Indian soils, by and large are low in organic matter and major nonlegume food grains: rice, wheat, maize, sorghum and millets yield very low without nitrogen fertilization. Phosphorus is very necessary on some soils, and is becoming depleted to levels limiting yields on some of the high producing irrigated lands. Potassium is needed in lesser quantity because some soils are inherently high in potassium containing parent materials. More recently the need for sulfur has been identified. An all-India coordinated project has identified vast areas in need of the micronutrients: zinc, iron and manganese, with copper and molybdenum on lesser scales.

India has over the past 30 years established many All-India Coordinated Projects addressing plant nutrition which are administered by ICAR. The ICAR research institutes, national research centers, state agricultural universities and some semi-autonomus institutions all have research programs in soil fertility and plant nutrition. Because fertilizer is a necessary and expensive input into the efforts to sustain the ever increasing demands for food grains, it has been placed on the National Essential Commodity list. The need to effect the coordination of plant nutrition research, develop improved technology, and better manage the supply of nutrients to plants in multiple cropping systems, has identified the need for a national level program in Integrated Nutrient Supply And Management (INSAM). The single global objective is to develop and to bring to the cultivator the most efficient fertilization-cropping systems technologies to intensify the economic productivity per unit of arable land.

C. The Present System.

The technology from INSAM, to pass from the researcher to the integration into packages of technolgy that can be taught to the cultivator, must pass through four separate entities. These are: (i) the researcher; (ii) those officers that control soil testing and have responsibilities for the training of extension workers; (iii) the soil testing laboratories in their interpretation of soil test values to give recommendations for fertilizer and other soil amendments; and (iv) the Subject Matter Specialist (SMS) or Village Level Worker (VLW) that work directly with the cultivators.

1. Research.

Research of primary importance to INSAM is generated by: (i) at least 6-8 all-India coordinated projects; (ii) ICAR institutions; (iii) national research centers; iv) state agriculture universities; and (v) some semi-autonomus institutions. Very active programs have generated worthy technology over the past 20-25 years.

A constraint preventing the projects from working more closely together has been the scattering of the national coordinators, resulting in a sense of isolation. India now has a very mature technical human and institutional resource base that was not in existence when some of the national programs commenced. Some of the present research needs have been identified as regional and not national, all this suggesting the necessity to rescope some of the national coordinated projects to encourage the flexibility to address some of the high priority regional needs.

2. Research Interpretation and Integration.

Much of research data are published in both national and international journals. Nearly all the data can be fourd in various annual and/or project reports. The gap has been the interpretation into educational programs that can be transferred and acepted by the cultivator. Specific research results also need to Le utilized for the preparation of tables and/or norms to interpret the analytical results from the over 441 soil testing laboratories into economic fertilizer recommendations. This technology trans-er system is almost completely under the administration of the state departments of agriculture which are not programatically responsible to ICAR nor to the state agricultural universities.

3. Soil Testing.

Soil testing laboratory numbers have increased from the 16 laboratories installed in the mid 1950's to over 441 with rated total capacity of 6.2 million samples annually. This calculates out to the capacity to analyze one soil sample for every 14 farm household annually. The system, on a national average, is presently operating at 74% of capacity. Nearly all laboratories are administered by the state departments of agriculture. Some laboratories are well equipped, capable of analyzing for micronutrients, while others are poorly equipped. Some laboratories are still using the tables imported with the first equipment to interpret and make recommendations based on soil test results, while other laboratories are using the most recent available tables prepared from local research. INSAM must view this situation as a major problem in effecicent nutrient management.

4. Technology Transfer.

Much of the contact with cultivators in the rural areas is by the VLW. The VLW is administered by the state department of agriculture. This position is at the low end of the pay scale. He is also saddled with many responsibilities that also detract from his ability to function as a effective agricultural extension agent. Some states have improved this delivery system through the use of higher level SMS's as backups to the VLW. A number of special programs have impacted upon cultivators resulting in increased productivity over the years. Even so, many farmers do not benefit from new technology, the reason being complex.

The director of INSAM must be mindful of all this; while not having direct control over all entities, he must strive to unify and mobilize these entities for better interchange and communication.

D. Strategy and Plan of Work.

The foundation from which to propose the agenda of INSAM is quite broad and has many fully operational programs. The major thrust must be in organization, research inventorying and speeding up the process of technology adaptation and transference of packages of technology useful to farmers.

1. General Organization.

A system to regionalize the all-India coordinated projects that will generate the technology for INSAM is suggested. This needs to include a mix of ICAR institutions and state universities to work out regional research needs within the guidelines of each of the all-India coordinated projects. A Regional and National Association of Soil Testers is suggested to bring the research interpretation process into the main stream. The ICAR is proposed to take the leadership role in these organizational developments. This will fit nicely with the plans to develop the Indian Institute of Soil Science. The coordinators for the all-India coordinated projects will be situated at the Institute to facilitate better interaction between projects.

2. Research.

Because of the volumes of research data already available, it is suggested that two phases be completed before entering into the final stages of major new thrusts in INSAM research. Stage one will be a research inventory process, stage two research priority planning, and stage three the long range research thrust addressing such subjects as, soil productivity index for targeted yields and nutrient balance modeling in multiple cropping systems. These stages should be completed in step-wise fashion.

3. Training and consultants.

Because of the relative maturity of the principals in the INSAM system, the training and consultantancy needs are very specific. Most can be completed through observation visits, workshops and specialized short courses. The exception might be a post-doctoral fellowship or short term sabbatical. There is much need for training in handling data on microcomputer systems. The necessary hardware, some of the software and training capacity are available in India. Observation visits to outstanding India institutions for both technical and operational strengthening are suggested to facilitate bringing certain activities up to speed. Consultants from the U.S. side will be short-term in nature and highly program selective.

4. Equipment.

There are needs for research equipment, field and laboratory, at many institutions to bring their INSAM research programs up to speed and quality. Many of these needs are outside the ICAR institutions, or control, and much of this equipment is manufactured and available within India. The specialized analytical equipment to strengthen and serve regional and national ICAR programs, and those needs to facilitate data processing and extension training have been identified and budgeted. The budget does include much equipment.

5. Budget.

The budget over the 5-years has been identified as follows;

Item	Total Cost (U.S.$)
Equipment	495,000
Training	1,518,250
Consultancies	486,600
Grand Total	2,499,850

No attempt was made to formulate a rupee budget within this subproject. A more complete breakdown of the dollar budget is shown in Appendix E.

6. Institutionalization.

The subproject will be administered by ICAR. The national program of INSAM, during the 5-years of this subproject, will move the present scattered centers for several of the all-India coordinated projects to the Indian Institute for Science at Bhopal to encourage cooperation and simplify communication. The national and state programs will remain separate administratively, but in the formation of representative regional workshops and committees it is expected that substantial integration will be achieved.

II. JUSTIFICATION FOR INTEGRATED NUTRIENT MANAGEMENT.

A. Introduction.

India is endowed with a wide range of climatic regimes, diverse soil types and abundant sunshine favoring high levels of biomass production in different ecological systems. The technological developments brought about during the last two decades in the agricultural systems have enabled the country to reach self-sufficiency in the production of food necessary for the growing population. The National Commission on Agriculture has estimated that the food grain requirement by the year 2000 A.D. will be of the order of 225 million metric tons per year. At the present growth rate, the population is expected to reach one billion, with a food grain requirement of 245 million metric tons. When population growth stabilizes during the 21st century at around 1.4 billion and with the steady growth in the purchasing power, the food grain requirement will be of the order of 350 million metric tons. Hence, to meet these future food, fiber, feed and fuel requirements, there is a need for continued growth in agriculture with optimum utilization of natural resources.

At present, sizeable areas of marginal lands which are best suited for pastures and social forestry are being cultivated for food crops. In line with the principles of ecological security and scientific land use pattern, such lands that are now under arable farming will have to be diverted to fodder, pasture and fuel wood production. With the available land resources being finite and inelastic, the only way to increase food grain production and also reduce the cultivatable area planted to food crops, will be by increasing the cropping intensity and the production per unit area.

In this context, multiple cropping assumes the foremost importance for increasing agricultural production per unit of land, water and time. Multiple cropping encompasses various cropping systems such as sequence cropping, relay cropping, row intercropping, mixed cropping, strip cropping and alley cropping.

The introduction of high yielding crop cultivars, expansion of controlled irrigation, and the increase in the intensity of cropping promoted during the seventies have amplified the deficiencies of macro, secondary and micro nutrient elements in many soils. To sustain this continuing increase in demand for food grains through a continuing increase in productivity from the agricultural sector, there is the need to increase the level of efficiency in use of inputs. This is especially true for the plant nutrients, because they are costliest as well as the key ingredients for high production cropping systems. Therefore, extension and rigorous monitoring of the available soil nutrient status through Integrated Nutrient Supply And Management (INSAM) will assume a place of prominence in research thrust on one hand, and extension recommendations to the farmers on the other.

B. Nutrient Dynamics in Multiple Cropping.

At different centers under the All-India Coordinated Agronomic Research Project, yield levels of 10 to 15.3 metric tons of cereal grains/ha/year have been demonstrated in multiple cropping rotations. The average grain production in these rotations comes to 40-48 kg/day. At these high cropping intensities, the average amount of N, P and K that must go into the plant works out to 1.7, 0.18 and 1.04 kg/per day, respectively. Inherent in the practice of multiple cropping is the concomitant need for using increasing quantities of plant nutrients. It is important, therefore, that the soils are managed to sustain high yields through the application of appropriate fertilizers and other amendments based on the level of nutrient already available in the soil.

Differences in the quantities of fertilization needed, based on the cropping system, reflect the great field to field differences because of the dynamics of the individual nutrients and their availability, both laterally in the surface and vertically within the soil profile. These soil nutrient supplying capacities need to be monitored by systematic soil sampling and analysis by the soil testing advisory service so that fertilizer use will be managed to yield the highest economic return.

C. **Gaps in Nutrient Management in Multiple Cropping.**

The fertilizer use practices and the changes in soil fertility status in multiple cropping systems are influenced by the following interacting factors:

1) The nutrient requirements and nature of the crop and their effect on the succeeding crop in the sequence; "or";

2) The nature of the cropping sequence itself (cereal-cereal rotations or rotations involving legumes grown for grain/fodder/green manure and various other combinations);

3) The nutrient capacity and nutrient supplying capacities of the soil;

4) The per cent utilization of nutrients from organic manures, biofertilizers and inorganic fertilizers and their residual effects;

5) The certainty of rainfall and/or irrigation to eliminate moisture as the most limiting variable;

6) The relative contribution of nutrients from surface and the subsoil based on the rooting characteristics of the plant and the physical and chemical properties of the soil;

7) The "legume effect" on nitrogen availability;

8) All of the above which are collectively expressed in the dynamics of soil fertility status (depletion/build-up) at intervals throuhout the cropping sequence; and

9) The size, education level and financial status of the farmer.

The research information available on nutrient supply and management use efficiecy is often limited to studies on one nutrient at a time, or on one crop from multi-location field experiments separated over a few seasons at different sites. In view of the above mentioned interacting factors, the nutrient requirements of the mutliple cropping system will not be equal to the sum of the nutrient requirement of the component crops. Although the effect of the first four factors has been studied separately, as single factor laboratory and field experiments, their net effect during the cropping sequence has seldom been quantified. Hence, there is a need to study and develop integrated nutrient supply and management for the various multiple cropping systems on a medium term basis (not less than 5 years), on well defined sites and extend their adoption to the field level amidst the farming community.

D. Trends in Cropping Intensity and Fertilizer Use.

The development and acceptance of short duration high yielding crop cultivars that are adapted for multiple cropping systems and the extension of irrigation in India greatly increased the cropping intensity. It is estimated that by 2000 A.D. the net area sown will be 150 million hectares. With the impetus given for increasing the irrigation potential in India under the 20 point program for national development, it is estimated that the gross irrigated area will be 113 million hectares with a cropping intensity of 133 percent. Corollary to the increase in irrigation potential and cropping intensity will be the commensurate increase in the consumption of fertilizer nutrients. Thus, from 1.32 million metric tons of fertilizer nutrients (N+P+K) that were consumed in 1967-68, the fertilizer nutrient consumption has risen up to 7.15 million metric tons in 1985-86. It is estimated that about 14-16 million metric tons of these primary plant nutrients will be required by 2000 A.D. to produce the predicted increase in food grain demand. Using a response ratio of 1:10, the additional 7 million metric tons of primary plant nutrients over the 1985-86 consumption would be needed to give the increased production of 70 million metric tons of food grain to reach the total production equivalent to 220 million metric tons by 2000 A.D.

A recent study by the National Council of Applied Economic Research has indicated that irrigated rice, wheat, sugarcane and cotton account for 80 per cent of the fertilizer nutrients consumed in India. The large scale adoption of the practice of more efficient use of fertilizers, based on soil testing and integrated nutrient supply for the envisaged cropping system to be perfected through this subproject, would enable the production of the expected food grain requirement from less than current cropped acreage. This should pave the way for diversified and scientific land use patterns in the country, providing for the expansion of agro-forestry, sylvi-pastoral and agri-horticultural systems on lands presently used for, but not totally suited for, food crops production.

E. Plant Nutrients: Sources and Efficient Use.

1) Organic Manures and Residues.

The value of organic manures in the cultivation of crops has been long practiced and appreciated in India. The various types of manures that are now available are;

i) Farmyard manure;
ii) Rural and urban compost;
iii) Green manure;
iv) Crop residues with and without nutrient enrichment;

v) Slurry from bio-gas plants;

vi) Organic-mineral fertilizers;

vii) Sewage sludge;

viii) Slaughter house wastes; and

ix) Organo-lignin-N prepared from waste products of pulp and paper industry.

Although the general value of organic manures for building up the soil productivity is well recognized, the immediate contribution to crop yield of the many organic materials has not been well quantified. It is necessary to identify the responsive soils and crops, the magnitude of response and fertilizer compensating effect of the various types of organic materials in multiple cropping systems. N enrichment levels need to be worked out for various organic materials to provide optimum C/N ratios in the soil for reducing nitrogen losses through immobilization.

2) Nitrogen.

Estimates show that Indian agriculture is operating at a net negative N balance, futher depleting soils of scarce organic matter. The production per unit of N requires more energy than that required for the production per unit of P and K. Field experiments have revealed that the recovery of fertilizer N by crops rarely exceeds 40 per cent of the applied N. Calculations show that a one per cent increase in the recovery rate of N fertilizer would result in a saving of 150,000 metric tons of urea which in terms of additional crop response would be equivalent to one million metric tons of food grain. Consistent with the theme of INSAM, increasing the efficiency of N utilization be perfected by use of indigenous materials which inhibit nitrification, such as Neem cake, Karen cake, and Mahua cake, use of slow release N fertilizers, urea super granules to permit precise placement, and other modified urea materials. Of high priority are research efforts that will enhance efficient use of N fertilizers, the production of which is dependent on finite and diminishing non-renewable fossil fuels, will enhance crop productivity.

3) Phosphorus.

Field experiments have shown that the recovery of P fertilizers by crops is no more than 25% of the amount added. Efficient use of P fertilizer is conditioned by the pH status and P fixing capacity of the soil. Accordance with the theme of INSAM, the following aspects need to be investigated as potential means to increase the crop utilization of the added phosphorus:

i) Direct application of indigenous and other rock phosphate and basic slag to appropriate crops in cropping systems on acid soils;

ii) Assessing the relative capacity of a range of grain and fodder legumes to mobilize the native residual P in the soil as well as in phosphatic rocks and partially acidulated phosphate rock, leading to the development of low cost amelioration techniques;

iii) Developing some best P application methods in relation to the rooting habit of the specific crops and the spacing used;

iv) Better definition of the economic return from fertilier P obtained over the range of soil test P levels.

4. Potassium.

Because it is a common practice to remove the total plant from the field during harvest, the position of K in Indian agriculture is also operating on a net negative balance. The delineation of K responsive crops and soils identified in relation to: (i) the K fixing capacity; (ii) soil texture and clay minerology; and (iv) K nutrition dynamics of different soils under intensive multiple cropping systems, would provide guidelines for the efficient use of K fertilizer. Calibration of a K soil test and its relationship between effective plant rooting depth and exchangeable subsoil K will need to be understood for improved K fertilizer management.

5) **Secondary and Micronutrients.**

With the advent of the Green Revolution and intensive cultivation of high yielding crop cultivars, emerging nutrient stress problems in Indian soils have been reported. The other contributing factors for such deficiencies are: (i) decreased recycling of crop residues and animal manures; (ii) use of high analysis, micronutrient-free fertilizers; and (iii) cultivation of marginal and problem soils. In the recent past, sulfur(s) deficiency, particularly in areas growing legumes and oilseeds, has been noticed in the light textured soils of Punjab, Haryana and parts of Himachal Pradesh. The research reported under the All-India Coordinated Project on Micronutrients in Soils and Plants reveals that out of more than 85,000 soil samples analyzed for micronutrients, deficiency of zinc (Zn) was the most widespread. More than one-half of these soils testing deficient in Zn are located in Haryana, Punjab, Uttar Pradesh, Madhya Pradesh and Andhra Pradesh. This has been substantiated by plant analysis as well as by significant field response by crops to the application of Zn. Average ocurrence of 11, 3, and 4 per cent for deficiencies in iron (Fe), manganese (Mn) and copper (Cu) respectively, were also indicated. Implementation of the concept of INSAM will go a long way toward the identification of soil-crop situations where nutrient stress to the secondary and micronutrients might energe.

6) Lime and Other Amendments.

The soils of India range from those that are very acid (being derived from lateritic material) to some possessing sodic and saline problems. The latter problem have been widely identified among some of the most productive and intensively cropped soils in India, and reclamation in the theme of INSAM offers opportunities for higher productivity from these soils. Soils that produce low yields, even under adequate or very high rainfall, because of acidity problems have been identified in some states. The integration of liming and/or other amendments into INSAM with the development of the most intensive cropping system will also increase the productivity of these soils.

III. REVIEW OF PRESENT ORGANIZATION AND PROGRAMS.

A. Introduction.

The programs encompassing Integrated Nutrient Supply And Management (INSAM) in Multiple Cropping Systems, from the researcher, who is charged with developing the basic technology, to the cultivator who must put this information into practice must pass through four (4) somewhat separate organizational entities. Those entities must be more strongly linked. The primary roles of and the programs of each of these organizationsal entities will be discussed individually.

B. Research Data Generation.

The research data base that is appicable to INSAM was found being generated from the; (a) all-India cordinated programs of ICAR; (b) the ICAR institutions; (c) State agricultural Universities; (d) a number of semi-autonomus institutions; and (e) various other programs all of which address one or more areas of INSAM. There are also a number of all-India coordinated commodity projects centered throughout the country. The team, because of time constraints, was unable to visit many of these centers and we therefore assume they address more the aspects of crop improvement and adaption and less in the area of plant nutrition and soil fertility.

1) All-India Coordinated Projects

The identified all-India coordinated projects that specifically address INSAM in multiple cropping systems are as follows;

i) All-India Coordinated Soil Test Crop Response Correlation Project. The calibration of fertilizer requirements for crops and cropping systems in relation to soil test values for specific yields. The fertilizer and organic materials nutrient efficiencies in terms of fertilizer standards and evaluation of soil test methods are all being investigated at 14 centers.

ii) All-India Coordinated Project on Long-Term Fertilizer Experiments. The response to manures and fertilizers on a long term basis in permanent manurial plots and their effect on soil productivity are being studied at 11 major agro-climatic centers.

iii) All-India Coordinated Agronomic Research Project. There are 45 model agronomic centers representing 15 major soil groups and 19 model agro-climatic zones. Production potentials and nutrient management of multiple cropping systems are being investigated under this project.

iv) All-India Coordinated Research roject for Dryland Agriculture. The possibilities for INSAM in sequence cropping, inter-cropping, agro-forestry should be investigated under these systems.

v) All-India Coordinated Project on Micronutrients in Soils and Plants. The delineation of micronutrient deficient areas based on critical limits for micronutrients and amelioration of micronutrient deficiencies are being investigated at 8 centers.

vi) All-India Coordinated Program on Microbiological Recycling of Farm and City wastes. The nutrient content, decomposition and fertilizer value of various organic materials are being investigated under this project at 8 centers.

While these and the All-India Coordinated Project on the Chemistry of Submerged Soils are considered the most prominant when bringing together research for INSAM, the following all-India projects also need to be considered as potential contributors to this proposal;

i) Biological nitrogen fixation by blue-green algae and azolla;

ii) Biological nitrogen fixation.

iii) Forage Crops;

iv) Agro-forestry;

v) Use of salt-affected soils and and saline soils;

vi) Soil physical conditions;

vii) Water management;

viii) Agricultural drainage;

ix) Diara lands; and

x) Agricultural meteorology.

The team also saw some very aggressive programs addressing the research of the rapid growing N fixing plants for green manure, a cropping system to adapt these plants into the system and fair quantification of the quantity of N supplied by these plants when used as a green manure crop.

2) ICAR Institutions

There are 35 ICAR institutions addressing agricultural research, some of which are centers for those all-India coordinated projects that address INSAM. There are 7 national research centers and 4 national bureaurs.

3) State Agricultural Universities

There are 26 State Agricultural Universities that are supported by their respective states that have charges for agricultural research, resident instruction and extension education in one form or another. The level of programs is highly dependent upon the support at the state level. To participate in an all-India coordinated project the ICAR will put up 75% of the funds and the State must supply 25%. Some of the universities are a center for one or more of the all-India coordinated projects. The team observed the desire of some universities to increase their research programs by becoming of the centers for those all-India coordinated projects that adresses research that would be of high priority for their state. Funding for state programs appears to also come from some ICAR projects, cooperative PL-480 projects, various other donors, industry and many other sources. Funds adequate for equipment, travel and other general operational costs are apparent problems at many State Universities. Even with these deficiencies, some very useable research data in support of INSAM have been generated and some very appropriate programs are underway. The team was impressed with the quantity of research with blue-green algae and azolla and the wide difference in results. Because of the position within the States and their charges, the Agricultural Universities can and should play a key role in this subproject of INSAM. Through the World Bank project, National Agricultural Research Project (NARP) zonal research centers are being developed in many, if not all states. It was the understanding of the team that these centers are strongly, if not wholly linked to the state agricultural universities and are so structured to bring adaptive research to the cultivators at the zonal level.

4) Semi-autonomus Institutions

Semi-autonomus institutions, such as the Potash Research Institute of India (PRII), that are involved in soil fertility and soil chemistry research that can add to the technology base of INSAM. These institutions also provide funding to some universities as an extension of their efforts and should continue to serve as part of the resource base for INSAM.

5) Overall preceptions

While the team did not have the opportunity or time to review each and every research project that potentially could add to the technical base of INSAM, it has some concerns for some of the programs and projects reviewed, both within and outside the all-India coordinated projects. There is a wealth of data available on crop response to N, some of which is documented to soil type and characteristics. This can serve as data bases for understanding yield potential for soil-cropping systems so that the concept of "targeted" yield could be tested over a broader base of soil-climatic conditions.

The plot design used for the multi-factor (N,P,K) linear response equation widely published is not statistically sound if used only for non-orthogonal regression equations because variables and treatments are randomized on pre-established fertilizer strips.

The large number of treatments in the factorial design add only bulk and degrees of freedom to the experiment. Initially, if response surfaces for the primary nutrients (N,P,K) would have been necessary, some simple 20-25 plot composite designs would have served the purpose to establish the levels for the control nutrients so that more manageable individual nutrient calibration experiments could have been utilized. The simple calibration to determine at what soil test level a economic response to P and K will be obtained is still badly needed in many areas. The use of available data as the data base to develop the best fit response models as yet has not been completely explored. Other specific suggestions will be enclosed in the Plan of Work.

C. Soil Testing Laboratories

Soil testing was introduced into India during the mid 1950's with the installation of 16 laboratories. The most recent summary reports 441 soil testing laboratories are now functioning in India, of which 101 are mobile laboratories, having the total capacity to analyze 6.2 million samples annually. Five states and three union territories have a laboratory in every district. A total of 4.5 million samples were analyzed in 1885-86, 74 per cent of the rated capacity, ranging from 103 per cent in Uttar Pradesh to 35 per cent in Orissa. There are also approximately 50 soil testing laboratories with the fertilizer industry serving some of their agronomic sales programs. About 90 per cent of the samples analyzed are submitted by Government functionaries.

For the most part, the administration and programation of the soil testing laboratories come under the State Departments of Agriculture. The exceptions being the soil testing laboratories at IARI, those at the state agricultural universities, and the fertilizer industry laboratories. Some special institional or project laboratories might also be functioning. Under the state system, as a general model, a chief chemist is generally administratively in charge of all the state laboratories, and in most situations, also a fertilizer control laboratory. Each laboratory is headed by a Chief Laboratory Officer, generally with at least a M.S., but not always in the soil chemistry-soil fertility discipline, or even in the discipline of soil science. Promotion to the position of Chief Laboratory Officer is based on service time and is not necessarily based on the individual's academic and experience credentials. This is viewed by the team as one of the constraints to the complete credibility of soil testing.

The bulk of the soil samples are collected by the Village Level Worker (VLW) and submitted to the laboratory. The VLW is under a quota, or "target" system to submit a given number of samples annually. The team was informed that because of the pressure to fulfill targets, cultivator fields were often sampled without his knowledge and probably no use is made of the analysis or the recommendation. The majority of samples are submitted before kharif (April-June) and before rabi (October-November) seasons. The mobile vans, being totally equipped units, move to remote locations where the analyses are made, interpretations are given directly to the farmer at the time and place of analysis. This service does not appear to be at all linked to the extension activities of the SMSs and the VLW's.

The routine analysis includes interpretations for N, P and K and some special reclamation amendments (acidic, saline, sodic problems) for which recommendations are given. Common analysis are pH, electrical conductivity (salt concentration), organic matter, organic carbon, Bray & Kurtz I or Olsen available P, K by 1 N N ammonium acetate and texture by the feel method. For acid soils lime requirement and alkali soils gypsum requirements are determined. Some laboratories, often designated as "mother laboratories", are equipped to analysis for Ca, Mg, S and the micronutrients, and interpret these analyze for recommendations. It was the understanding of the team that those samples submitted for special analyses come directly from the cultivators and did not come through the VLW.

Normal turnaround time for routine sample analysis and interpretation is about two weeks. Some states report putting extra shifts on during the rush season to insure timely completion of the analysis. The fertility level is reported to the farmer as low, medium and high, which apparently causes confusion.

The recommendations based on the laboratory test are completed by the senior soil testing Officer. He uses the guidelines that come through the chief chemist, some of which are state-of-the-art technology and some still based on the 1950's guidelines imported with the first laboratories. There appears to be a reluctance by some State chief chemists to accept the most recent imterpretation data from the All-India Coordinated Project on Soil Test-Crop Response developed regression equations which apply to specific crops on carefully matched soils and climate. Some states have active committese to keep their fertilzer interpretation system up to date.

There was mentioned on several visits programs to train the officers in charge of the soil testing laboratories, but the team was not able to determine if this training reached down to the level of workers in the laboratory itself. There is apparently a fairly high turnover rate in soil testing laboratory personnel that requires a constant training activity.

At one time there apparently was national coordination of the soil testing laboratories when all the data were sent to a central location where some soil fertility maps were constructed. This ceased about 1974-75 and now states develop soil fertility maps individually, some states fairly regularily, and some states not at all. It would not seem feasible to store centrally, just for centralization purposes only, the soil test values from 4.5 million samples analyzed on an annual bases.

The team had the opportunity to visit only a few of the 441 soil testing laboratories, and none of the mobile vans or fertilizer industry laboratories. The capacity and quality of soil testing can not be evaluated from these few visits. It was apparent that equipment necessary for routine analysis is manufactured and available from many suppliers in India. The atomic absorption capacity for micronutrients is needed in some, but certainly not all laboratories. The actual equipment available in each laboratory, by virtue of these laboratories being under state administration, is probably only known at the state level.

There was not a clear cut program identified in quality control, such as precision of analysis, need to come within certain limits etc, through a process of sample exchanges. Standard samples are available, but it was not clear whether laboratories used standard samples routinely or received blind samples from time to time.

The degree of integration of the soil testing laboratories into the extension activities and their linkage to interpretation of recent research varied from state to state. The concept that soil testing should be a soil fertility management tool to apply the best fertilizer nutrient management program for most economic crop production does not appear to be fully accepted. In some states the laboratory only analyzes the soil samples, mails out the recommendations, while in other states the laboratories conducted verification trials and the soil testing program was strongly linked to a total extension program.

The team was concerned about the units in which the fertilizer recommendations are expressed, especially when mailed directly to the cultivator, or whether this information could or would be readily understood or used. Keeping in mind that the level of final education of the rural cultivator is at the lower end of the national scale. He may not understand this information even when presented in the local language. The availability of a trained VLW would be very helpful.

D. Research Interpretation and Transfer

1. Background

Although it is very difficult to assess the degree of utilization of research results within so short a time, it seems that there is too little use made of the results already firmly established. There is a lot of excellent Indian research on soil chemistry and response to added plant nutrients, dating back 20 or more years, but almost identical experiments are being repeated currently. It is not for lack of documentation. The team was shown a great number of reports prepared by the institutions visited. The summary reports of the all-India coordinated projects brought together results countrywide. Articles in the Indian Journal of Agricultural Sciences and papers presented before the Indian Soil Science Society are a permanent record of the research completed. Foreign journals also accept articles prepared by Indian scientists and these are available on most campuses.

2. Assessment of constraints

There is a need to explore the limits of the plant nutrient supply system under well defined soil-crop systems rather than to repeat patterns already fully established. This research should be directed at current or potential profitable cropping sequences spanning three, five or more years. Fertility experiments need to be planned on the basis of the best soil analyses available. The need for additional N for satisfactory crop yield does not have to be proven. The need for P and K is equally certain and reliable soil tests are available to predict the probable response. The base for further experiments should be the optimum levels of all of the essential nutrients except those of immediate concern. Where depletion rates are to be determined, maximum yields should be sought to stress the systems to the maximum degree. If a soil is well supplied with the nutrient of concern, there is little value in sampling and testing on a crop by crop or even an annual basis. The time can best be used for other research. Crops field experiments must be well managed to obtain reliable yield data. It may be adviseable to quantify nutrient removal but even this only need be done only periodically with composite samples.

The INSAM subproject was indentified recognizing this as one of the major contraints. With all the manpower devoted to research and extension activities, it is not feasible to provide farmers with prescription recommendations on a crop by crop basis. It is essential that plant nutrient supply schedules be provided for extended periods, no less than three years and more practically for five years. Much of this can be done utilizing the results already in hand. Much data are available on plant nutrient removal. It is easy to estimate the extent of probable plant residue return.

The use of manure is clearly based on availability. The possible contribution from manure can be readily calculated from the supply. New experiments should be planned to continue over rather extended periods with systematic monitoring at appropriate intervals. They should focus on problems of the soils and crops found in the area of interest to the scientist.

In most cases the probable returns from suboptimum rates of application of essential elements can be estimated without developing new response curves. The data need to be interpreted so as to give the farmer realisitc expectations of his crop yields based on the quatity of fertilizer he will apply. The "target yield concept" provides the basic information, and equations but further calculation is needed to maximize the returns to a farmer based on his available resources. Cash available to purchase inputs is most often cited as one of the principal contraint. Access to additional land is an even more serious constraint in a country as densely populated as rural India. Realistic income goals based on available capital to purchase fertilizer should certainly be one of the targets. A challenge to INSAM research will be to model the dynamics of soil productivity index and climate into realistic target yields or the yield potential of the cropping system based on balanced fertilization. Where commodity prices are known in advance, the range of expectations can be calculated. The individual's risk assessment will finally determine how much he is willing to invest in purchased inputs, but even on this, records already available can help make this decision. Rainfall probablity data are among the most critical for formal risk assessment. Farmers do the same intuitively or by following established practices. What will need to be interpreted are needs on the basis of the water holding capacity of the farm soil and the root volume of the particular crop. At high altitudes frost may be a consideration during winter months. In coastal areas water and wind damage to crops can over-ride any fertilizer program. On the floodplains of the continental river system crop loss during kharif is all too real a possibilty.

3. Research Challenges

Considering all the information that is available, where are the research gaps and future priorities? Long range depletion studies have been discussed in terms of nutrients. Acidification is predictable for many soils that are now neutral or only slightly acid. Aluminum and possibly manganese toxicity are already problems in some of the strongly acid soils and will become even more serious when the nitrogen requirements of crops are fully met. Much excellent work has identified micronutrient deficiencies, but the extent of the deficiency and the soils affected need to be more sharply delineated. The range between the safe use and excess quantity of these critial nutrients is relatively narrow, with excessive use being more damaging than a mild deficiency. The sources of these nutrients are also relatively costly and no more should be recommended than is absolutely necessary to obtain a satisfactory yield on a particular soil.

There is already a national program to strengthen dryland agriculture. Integrated nutrient management is as important in rainfed crops as in irrigated ones. In fact, inadequate nutrient supply is often the cause of crop failure attributed to moisture stress. Where root development and access to soil moisture are limited by aluminum and manganese toxicity, even short periods of drought may reduce yields significantly. In many soils phosphate availability is limited under moisture stress and higher levels of soil P are required to encourage growth of a normal root system. An excessive supply of N may inhibit root extension and must be avoided. Micronutrients are often more critical in dryland agriculture than in well watered areas, especially where the soils are neutral or alkaline. Unfortunately, crops traditionally by grown in the drier rainfed areas are relatively low value crops which brings us back to the subject of limited return on expenditure.

More attention may be given to nontraditional crops, especially high value crops. With India over the threshold of self-sufficiency in basic foodgrains, alternate crops must receive attention. These are not the traditional crops for soil scientists and agronomists. Finally, in considering integrated crop management, continual attention must be focussed on returns to input costs. This cannot be left to the economist but must be used continually as a guide by the soil scientist, agronomist and horticulturalist.

Organic fertilizers, i.e crop residues, manures, cover crops, legumes in rotation and nonconvential nitrogen fixing systems such as blue-green algae and azolla are looked to as alternatives to purchased fertilizer. Much data are available on their potential contribution with projections on their utility in crop production. Waste materials must be recycled but their value in alternate uses must also be considered. The fuel value of dung is greater than the value of its nutrient content. Even the mineral elements in the ash are seldom returned to the field where the orginal fodder was grown.

Biogas plants appear to provide an answer to this puzzle but they are costly and can be troublesome. They are certainly less reliable than the traditional dung fire. Wheat straw is customarily fed to animals and again is more valuable as a feed than as a soil amendment. Legume crops may contribute considerable N to the rotation but much of it is removed with the harvested crop or fodder. Still the quantity of residual N is significant, as is well documented. What we need to learn or assess is why the acknowledged value is not being utilized. Is the rhizobium consistently effective, or only when employed by a trained research worker? Have farmers been sold so many miracles in small packets of powder that they simply reject any new similarily packaged products? Is the problem one of packaging and viability retention in what are initially effective inoculants? Does a cover crop really fit into the cropping cycle from a farmer's point of view? There are certainly many reasons for the extremely slow acceptance or the rejection of this practice, but the reasons may have to be discovered outside the fields of microbiology, agronomy and soil science. Perhaps the interval between major cropping seasons provides the farmer with time to regain his strength to face the next traditional crop. The additional work and the timely availability of water for a nursery are frequently cited as the reasons that Azolla has not been generally accepted. Blue-green algae show promise but seems not to have caught on except in the extreme South. The technology of its use seems to have been worked out quite throughly. What makes farmers hestitant to adopt their use?

4. Communication Challenges

The institutional separation of the research programs and soil testing service programs creates a special problem. The extent of linkage varies widely among the states visted but even for the best situations, closer ties between the research and the soil testing laboratory are essential. This situation in not unique to India. It is a continual challenge in all countries. Coordinating committees are useful but usually involve only the administrative officers or supervising scientists. Workshops involving the active scientists and agronomists attached to the soil testing laboratories should be arranged frequently to arrive at more discriminating fertility management recommendations. There will always have to be a compromise between very precise site specific recommmendations and universal crop recommendations. The soil testing laboratory agronomist must also be aware of the strengths and the weaknesses of those who are the bridge between him and the farmer.

E. Technology Transfer to Cultivators.

1. Purpose of Extension.

One of the major purposes of extension is to deliver or transfer appropriate technology and other education to rural families so they might improve their quality of life. In agriculture, this will also include not only the farmer, but much of the agri-business community that must bring goods and services to the rural areas. In much of India, extension does not mean only education, but also means the delivery of goods and services. The Indian extension worker, by and large, are administered through the State Departments of Agriculture through a series of administrative channels so that extension is commonly the charge of the Village Level Worker (VLW) dispersed throughout the rural areas. While the role of the extension agents has changed over the past 30-40 years, he still often is charged with many activities that are not related to production agriculture, or even with agriculture at all. The degree of and need for technical backup to the VLW in the form of M.S. and/or Ph.D. level Subject Matter Specialists (SMSs) has been identified in some states and the quality of the extension program was found to vary from state to state.

2. The State Extension Organization.

The diagram in Figure 1 illustrates the arrangement of the extension personnel (horizontal and vertical) with the State Department of Agriculture of Orissa and is a example of the administrative position of extension within the State Government. Greater detail will be given to the components that relate to the transfer of technology in activities referred to as extension. The section addressing agriculture technology transfer is presented in Figure 2, magnifying the "flow" of information from the SMS (research link) about Integrated Nutrient Supply And Management (INSAM) in multiple cropping systems through the VLW to the cultivator.

The VLW is the last person in the technology transfer or dissemination system that interacts to bring the information on improved agriculture production practices to the cultivator. In this example (Orissa) there are 5,911 VLW's to work with 3 to 4 million rural hoseholds. Each VLW would average 592 families. The flow of technology through the SMS down through the District Agricultural Officer (DAO), Additional District Officer (ADO), Agricultural Extension Officer (AEO) and VLW to the cultivator becomes a formidable task.

In some states, in order to achieve a more efficient contact with individual farmers, the VLW selects about 10 "lead" farmers who in turn enroll about 60 farmers with which they will work. These lead farmers may encourage their enlistees with the selected production practices to be undertaken, empasizing their value and following up to see that they are completed. One can see that the multiplier effect is utilized to greatest extent possible for improving the farmer's welfare.

It must be remembered that the VLW is burdened with many tasks such as;

i) allocation of seed and pesticide;

ii) allocation of fertilizers and other soil amendments;

iii) soil sample collection, transmittal and interpretation of the recommendations for suggesting fertilizer purchases;

iv) family planning strategies;

v) advice regarding financial support; and

vi) census and other data collection; and many other non-agricultural charges and responsibilities.

In many districts the educational level of the VLW is equivalent to high school, and some with post-high school up to the B.S. degree. Much effort has been addressed to the upgrading of the salary scale and educational level required of the VLW. The lack of means to travel travel funds, education and demonstration materials were stated as constraints to effective extension technology transfer activities of the VLW.

3. State Agricultural University Extension Programs.

a. General Extension Activities.

Throughout India the State Agricultural Universities were found to have active extension programs to train SMS's, VLW's and other extension type poeple, and in some cases worked directly with the cultivator in efforts to speed up the transfer of technology. Some Universities have received specially allocated resources and have developed very effective programs, while some with very little funding and staff support, have very limited programs.

The example to be discussed below was observed by the team to be one of the more strongly supported and staffed state agricultural university systems in India. The success of the programs in this system could, with modification, be used as models that could be adopted by other state agricultural universities. At Haryana Agricultural University (HAU), a team of 12 Subject Matter Specialist (SMS), in consultation with their respective Department Heads, is responsible for planning and supervising various extension activities. An important feature of the HAU system has been the establishment of Krishi Gyan Kendras (KGK's) in each district. At each KGK there are 11 local SMS's. These KGK's are the hub for extension education activities, many locations having rooms for training, and some laboratories that diagnose some plant and soil problems. Agricultural Officers Workshops (ADW's) are held twice a year, February/March and September, for kharif and rabi crops, respectively, for finalization of technical recommendations. These are attended by the senior Department of Agriculture officicals and university scientists at which time they discuss their farm problems and research findings and develop recommendations, which are later published in "Pakages of Practices" for the kharif and rabi crops.

The AOW's provide a unique opportunity for interaction between the scientist and field functionaries, which is beneficial to strengthening extension education, technology transfer and identify adaptive research needs at the farm level. Soon after these workshops, one day District Level Training Camps are organized where all department of agriculture extension functionaires meet and receive technical information.

Another major extension activity has organized farmer and family visits to the University called "Kisan Mela" and "Farm Doorshan". They are held in March and September, respectively. Thousands of farmers visit the University where they are shown many kinds of demonstrations, special or model demonstrations on crop cultivation and production practices for the new crops. Seed is often also sold at this time. Usually, much time is devoted to question and answer sessions where farmers can obtain responses from the scientist about their field problems. In addition, the KVKs have organized Mini Kisan Melas every year in kharif and rabi season as "adopted villages". Crop competitions, livestck shows, clinics (for both animal and crops) are also organized.

b. **Lab to Land Program.**

In 1979, the program "Lab to Land" was entered into by many Soil Science and Agronomy Departments in the State Agricultural University replacing a earlier program referred to as "Operational Research Projects". Farmers with small (0.2 to 2.0 hectares) farms are selected. Latest technology in soil science, fertilizer use and proven production practices are demostrated to the cultivator to teach him new technolgy anticipating he well adopt new methods to obtain higher yields. In addition, researchers are afforded the opportunity to learn if their technology is relevant and if it can be readily adopted by the cultivators who have limited land and monetary resources.

It was reported from some states that researchers work or test their practices in cultivator fields working cooperatively with the State Department of Agriculture.

4. Field Demonstrations.

Field demonstrations were repeatedly mentioned as a very wide spread method to show first hand to the cultivators emerging and proven new technology. The extension specialist from the state departments of agriculture, state agricultural universities, ICAR institutions and agricultural industry, place various crop demonstrations i.e., winter maize, wheat, rice, jowar etc., directly in cultivator fields. These demonstrations may ecompass: sources rates of fertilizers, blue-green algae, azolla, time of fertilizer application, water management, limited resource inputs, crop protection methods, just to list a few. These are shown to the surrounding cultivators during the growing season, harvested and the difference in (grain and/or fodder) yields are measured and emphasized. Often this is organized with a Farmers Fair or Harvest Festival to display and discuss the results of the demonstration.

5. Mass Communication Systems.

With the development of the the All-India Radio system and the wide ownership of radios, that has become a popular method to cummunicate with cultivators and village poeple. Radio scripts are prepared by University SMS's on many agriculture production subjects, such as, use of fertilzers, important crops, plant protection, etc, and are distributed to strategically located stations for timely transmission. Some programs have also be developed for television, but as of todate, the coverage by TV will not affect the normal cultivator. Commericals to popularize fertilizers, plant protection chemicals etc are common on both radio and television.

6. Education Materials.

Throughout India, numerous kinds of leaflets, bulletins, display charts, small posters and other printed pieces containing "how to do it" materials are widely passed out to interested people. There is a concerted effort to prepare these materials in the most appropriate local language so that the literate cultivator can benefit from the information.

7. Role of the Fertilizer Industry.

The fertilizer industry has very active programs promoting the use of fertilizers, particularily their own brands. They also have some developmental programs aimed to bring new technology to the cultivator. For example, in 1975, every fertilizer company in India was asked to adopt a few villages (total of 63 were adopted) in their operating areas with the objective of introducing the concepts of maintaining soil fertility and sustaining productivity through efficient use of organic manures, chemical fertilizers and biological N fixation. The important component of this industry program was the use of soil testing to give fertilizer recommendations to increase the cultivator's income. Numerous field demonstrations were established throughout villages, under the supervision of experienced agricultural graduates who lived in or nearby the adopted village. Some field demonstrations required limited monetary inputs, demonstrated optimum dates of planting, row planting, use of urea etc. In some situations subsidies were given that were restricted to the demonstration fields.

Another fertilizer industry sponsored promotional educational program is that of the Hindustan Fertilizer Corporation Ltd., functioning in Bihar, West Bengal and Orissa. This is referred to as the Indo-British Fertilizer Education Project, receiving sponsorship from the United Kingdom. The objective is to demonstrate the proper use of fertilizers based on scientific principles. A particularily useful "project manual" with crop production guidelines for dryland/rainfed agriculture has been developed for use by the farmers. A package of practices is implemented for at least two years on selected farms that must improve the cropping pattern and the crop yields. A detailed economic analysis is completed on the yield increases relative to the profitability of rice, pulses and selected oil seed crops. The project has successfully completed phase I and phase II, to commence with kharif 1987, has been approved. Phase II will also include a followup survey to determined degree of adoption by the cultivators in the areas covered in the phase I.

8. Weaknesses in the Technology Transfer System.

Although considerable impact has been achieved over the past 25 years to transfer technology to increase food grain production, several are weaknesses observed in the extension or technology transfer system such that many cultivators are still do not benifit from the modern technology of INSAM. Some of the preceived weaknesses are:

i) Generally the educational level of the VLW is too low (high school) to understand and transfer the technology of INSAM as it fits into modern cropping systems and farming systems. He often has no practical experience and is not well accepted by the cultivator.

ii) The VLW is asked to handle many chores outside addressing the transfer of agriculture technology to the cultivator. He is also somewhat physically, administratively and program wise completely isolated from the centers of technology development and programs such as soil testing that can expand the acceptance of INSAM.

iii) The concept of measuring success by meeting the targets as the yardsticks does not insure that any success in technology transfer has even occurred. His position within the state department of agriculture places him in a poor position to communicate the cultivator problems back to the researcher and find help to improve his position through use of modern agriculture technology.

iv) The lack of travel money, mode of transportation and funds for education and demonstrational materials also are constraints to the productivity of SMS's and the VLW's.

IV. SUBPROJECT STRATEGY AND PLAN OF WORK.

INSAM will bring exisiting activities, projects and programs together, assisting effective interaction and providing support. It will not replace them nor will it become another all-India coordinated program. The research and extension under INSAM has a number of operating components, some of which are of greater strength than others, but all have their individual strengths, and each has activities that are in need of strengthening. INSAM is intended to be "national in scope" and will increase productivity per unit area of food crops and conserve purchased inputs such as fertilizer, lime, gypsum and other soil amendments. It is also intended to enable the diversion of some of the less desireable crop land into wood and fuel production.

This subproject will address some of the overall needs to bring together the necessary components of INSAM in: (a) adaptive research; (b) research transfer to soil calibration and interpretation; (c) the operations of soil testing, and; (d) the linkage and utilization of soil testing and interpretation in the farming systems as they relate to INSAM in multiple cropping systems (Figure 3).

INSAM as a total program must be non-institutionalized and come together within each state. This subproject must keep in mind in its execution the following: (a) the contributions from the all-India projects that are addressing the research on soil fertility, plant nutrition and soil chemistry; (b) the responsibilities of the state departments of agriculture; (c) the research, education and extension roles of the state agricultural universities; (d) roles of semi-autonomous institutions and (e) the roles that the fertilizer and other industries must play.

A. Functional Organizational Network.

1. Coordinated Research Network of INSAM.

The conceptionalized network of INSAM is illustrated in Figure 4. The regions shcwn are the chart are illustrative only. The number of regions established will depend on logical groupings of soil and crop management units. Too few will combine areas with little in common. Too many will make the group so small that it includes too few people to provide natural leaders and a stimulating range of training and experience among the participants. The all-India coordinated projects as described in Section III. A. "Research Data Generation", will be maintained as functional programs in their present status as operating all-India projects. This concept of all-India coordinated projects is a sound unifying program to bring agriculture research to many states as a national program.

The level of technology generated has served well to increase food production to the level of national self-sufficiency, but refinement of research, specifically targeted research and improvements in research infrastructure are needed for the future. Bringing together the all-India coordinated projects and other contributing programs and the respective scientist and technology delvery system will be a major charge of INSAM.

a) Regional Coordination

The concept of a logical division of the country into regions, either by state or major agro-ecological zones, is needed to bring those scientists together that might have common problems and/or need to work together. A visual presentation of this research program configuration is presented in Figure 5. Within each region, particpants from the all-India coordinated projects, the ICAR institutions, national research centers and state universities should develop a five year research plan of work addressing the highest priority research need as determined by the researchers. This first step should be to convene a workshop for taking stock of the current plant nutrient management research with the broadest practical representation. After the proceedings of the workshop have been circulated for comments a steering committee could decide on the timing and purposes of subsequent workshops or specialized working groups. This would permit regional and local selectivity for determining the highest priority research needs. These regional proposals would be incorporated into the all-India coordinated projects by the scientist that is now the national coordinator. It would also be helpful to select, under deputation and on a part time basis, a Director of research or a senior researcher to serve as a regional liaison to assist in coordinating the project's activities. He should serve as the chairman or convener of the steering committee made up of the ranking regional officers or their designates from each of the cooperating programs or institutions. Each region would meet annually, 1-2 days, to discuss results and work to unify reports, making recommendations and interpretations as they see necessary. In addition, annual regional meetings of the total all-India coordinated projects that contribute to the technology base of INSAM would bring all the researchers together to facilitate integrating their research on practical adaptation. National level workshops of each all-India coordinated project at 2-3 year intervals would serve to keep the national concept in place.

This would require that those state agricultural universities and ICAR institutions that want to be in the all-India coordinated programs be given this opportunity and provided with the support to become active and contributing institutions. Division of program responsiblities could be worked out between cooperating institutions similar to the present guidelines, or as what would appear as adequate.

2. Technology Utilization Needs and Suggestions.

i) Strengthening of the Soil Testing Laboratories.

There are presently 441 soil testing laboratories in India, of which 101 are mobile laboratories, with the overall capacity to analyze 6.2 million samples annually. As the national average, 74 per cent of the capacity is being utilized with a range among states of 35 to 103 per cent. There are also approximately 50 soil testing laboratories within the fertilizer industry that serve their agronomic sales programs. About 90 per cent of the soil samples tested come from Government functionaries. There are an estimated 89 million farm holdings in India, which means on an annual basis, that one in every 14 holdings could receive the service of soil testing annually, if the laboratories achieved rated capacity.

This should not imply that a large increase in the number of soil testing laboratories is needed to insure that all holdings will be able to receive annual soil testing. Some land holders might never use soil testing; some holdings are such that soil testing is of little value. Therefore, a once in every 3 to 5 years analysis and recommendation system is suggested to utilize the soil test interpretation for representative farms as the "nutrient management tool" or "fertilizer purchasing management tool" in multiple cropping programs. Serving the farming systems should be the goal of the soil testing programs, not sampling, testing and recommendation on a prescription basis. Sampling by extension or research personnel and testing for diagnosis of problems should still be continued, but on a very selective basis.

Because the functioning of the soil testing laboratories is the responsibility of the individual state departments of agriculture, and also because of the sheer number alone, supervision on a national scale would be impossible. There were some perceived difficulties with the operation and capabilities of the laboratories in some if not all the states visited. Some states had what was considered a "mother laboratory" around which other laboratories were clustered while in other states each laboratory functioned as a individual unit. The strength of a state soil testing program was found to depend on the level of education, scientific specialization and other strengths of the individual in charge of soil testing in the state.

The director of the mother laboratory and leader of the state soil testing program should hold a Ph.D degree in soil fertility-soil chemistry. A minimum of a M.Sc. degree in soils or agronomy should be required for managers of each other laboratory in the state.

ii) State Organization.

Each state should have one or more mother laboratories, dependent upon the number of laboratories within each state. This would mean some states would need more than one regional mother laboratory while other states can get by easily with one such laboratory. This mother laboratory would be equiped with the capacity to analyze for the secondary and micrconutrients, and serve as the local spare instrument-parts-minor repair depository to facilitate keeping all laboratories under its jurisdiction running up to speed. It might also serve as the central purchasing agent to facilitate purchases of supplies and to obtain volume discounts. This laboratory would also serve to send out check samples for quality control and serve in trouble shooting. Data collection and storage by computer on a national standard format should be initiated at this site. Soil fertility maps could be developed at the state and district level from these data. The data could be integrated electronically at the national level to feed into the national soil fertility data base. From this data base rather sophisticated digitalized soil fertility maps could be preapared by positional soil-landscape configurations.

For operational unity, only the mother labs need be capable of analyzing for the secondary and micronutrients. They should receive these samples after the routine analyses, from those laboratories under their tutelage. A fee should be charged for those analyses desired in addition to routine analyses, i.e. secondary and micronutrients, as an indication of their cost and to restrict the number of samples. Only cultivators that have a sincere interest in the additional analyses will submit samples if there is a charge. This system also would help link the mother labs to the other laboratories within the region.

iii) National Coordination.

To develop some organizational framework for soil testing on the national level, so that principal officiers in charge might be integrated into INSAM, a national working group of soil testers should be organized as illustrated in Figure 6. Annual workshops centered around those aspects of soil testing and interpretations for making recommendations for fertilizers and soil amendments as needed for change occur or special problems might need attention should be organized in each region. Training, soil testing promotion and field validation could also be some of the topics of importance for regional discussions. The leaders of the various cooperating programs in the region should rotate as organizers of the workshops. The officers of the mother labs would meet on a national scale, attend the INSAM workshops and serve as the conduit to bring needed program changes to each of the laboratories for which they have responsibility. This should afford a system of interchange to bring and keep the soil testing and interpretation programs up to the state-of-the-art, and with the most recent technolgy that is generated by the all-India coordinated projects feeding into INSAM.

B. RESEARCH NEEDS AND SUGGESTIONS.

The all-India coordinated projects that should provide much of the technology base for INSAM were presented in section III, A. "Research Data Generation", and will not be repeated here. Inventorying the present level of technology, so as not to repeat what is already completed and well documented, and prioritizing both short and long term research needs, must be completed. This subproject can not undertake the enhancement of all the disciplines of soil science.

1. Use of Present Research Data, Stage One.

Soil fertility-plant nutrition research completed by the all-India coordinated projects, ICAR institutions, state universities and other institutions needs to be synthesized into systems for utilization in the INSAM subproject. Waiting until all data are perfect will not insure that any of the research will ever be utilized. While some of the research has been developed into applicable technology that can be used or can be transferred to the cultivator by extension worker or subject matter specialist, much still remains in scientific papers and technical reports. Some fault can fall upon the system of data evaluation or lack of evaluation of the research. The multi-variable regression equations can provide high coefficients of correlation for linear equations but might and probably do not provide the best analytical tools and basis for recommending the most economical quantity of fertilizer and/or soil amendment that the cultivator should apply, based on a soil test.

INSAM should provide research leaders a forum to explain that balanced fertilization means providing the necessary supplement of plant nutrients to those available in the soil that the maximum use is made of the farmers' most limiting resource. Unfortunately, much of the promotion of balanced fertilizer is still based on a pre-selected and convenient ration of N:P:K in the fertilizer. In fact, the ratio or analysis of the fertilizer dose is likely to change for the same field depending on the intensity of use and the money the farmer has to invest.

Another of the first charges of INSAM is, through a series of regional workshops, to bring together all the valid data from the all-India coordinated projects and other sources to develop the best possible responses to the following integrated nutrient management needs:

i) The quantity of N that would provide the highest economic responses in a cropping system;

ii) The soil test level above which a response to P and K would not be expected and below which a response would be obtained and the most economic quantity to apply;

iii) The soil test required, amendments needed and the available and economic quantities of these amendments that would profitably improve yields on saline, sodic and acid soils;

iv) Identification of soils with high probability of having a micronutrient deficiency, a micronutrient soil test value below which a economic response would be obtained and the crops that would be most responsive to the micronutrient;

v) A chart or other interpretation system to estimate the reasonable contribution of nutrients from manures, composts, organic residues, blue-green algae, green manures, azospirillum, legume intercropping, residual N following legumes, and any other contributor so that the SMS and VLW might better guide the fertilizer N purchases of the cultivator;

vi) An efficient system is essential to incorporate the available information on water management/soil moisture intraction with fertilizers if the full value of the inputs is to be realized;

vii) A simulated fertilization system that will fit recommendations based on the soil test into the number of crops in multiple cropping systems. This should include quantities to apply, in what sequence the individual nutrients should be applied to obtain the most efficient nutrient use and economic yields.

To formulate this information will require bringing together the best available data and their interpretation from at least eight of the all-India coordinated projects listed in section III, A. "Research Data Generation" and from the other institutions of agriculture research. A suggested model for an integration workshop to inventory and develop some fertilizer use recommendations from present data is presented in Table 7. Upon completing of this activity of compilation, interpretation and formulation of research into useable forms for best possible utilization, Stage Two, "Research Priority Planning" can be undertaken. The completion of Stage One would help INSAM to think through and see the gaps in available technology that could become high priority needs in Stage Two.

2. Research Priority Planning, Stage Two.

The purpose of the research priority planning will be to identify: a) technology or research information that is presently adequate or near adequate or have programs underway that should provide this information to INSAM; b) technology or research that needs refinement or some additional research effort to enhance INSAM; c) research information that is transferable over fairly wide agro-climatic zones so as not to be unduly repeated; and d) major gaps in the present information and research programs that will demand attention and new research efforts.

The research priority planning should be based on all the relevant scientific principles and state-of-the-art technolgy which relate multiple cropping systems to soil type, landscape position and climate to: (a) individual crops; (b) nutrient balance in cropping systems; (c) yield target identification; (d) specific soil reclamation-amendment needs; (e) best possible use of indigenous soil amending and nutrient supplying materials; and (f) other specific needs that can be identified by the researchers in the various institutions. There are some representative research priority planning models available that can be modified, made open ended so as to facilitate adding and deletion of resesarch areas according to what a panel of research planners may see as important. A suggested approach or approaches are presented in Table 8.

3. Long-Term Integrated Research Needs, Phase Three.

The research that should be included in this section would not be expected to be concluded within the time frame of this subproject, in fact, a good beginning would be considered as very acceptable progress. The interdisciplinary nature of the research will require careful planning to insure a reasonable level of success.

. i) Soil Productivity Index and Target Yield Determinations.

The need to develop a discriptive diagnostic method to be able predict a yield potential or realistic yield target based on the climate, known physical and chemical properties of the soil and respones to fertilization and amendents was identified in the many visits as a high priority reseach need. This research will require inputs from soil genesis, soil physics, soil chemistry, soil fertility, water management and use and agrometeorology. The selection of a few test sites representing some of the major soil-climatic zones that have completed soil surveys should be undertaken first. The characterization of soil physical and chemical properties must first be determined, the then properties amendable serving as treatment variables in the models. This is one area where intermittent consulting from a U.S. scientist and short term observations in the United States will be of great benefit. A scientist-to-scientist linkage would be preferred.

ii) Balance Sheet of Nutrients and INSAM of Multiple Cropping.

Developing a record of change in the availability of plant nutrients by testing soil samples from the same field every three to five years will provide a reasonable basis for making and adjusting fertilizer recommenations. Both research officers and extension workers supported this approach. If the nutrient removal is also monitored, it becomes possible to create a balance sheet. All contributions and drawdowns are accounted for: fertilizer, lime, manure, additions from legumes, release of nutrients from primary minerals or reserves of fixed nutrients applied in the past and nutrients removed in fruit, fodder, grain and straw. The concept of balance sheet and/or systems approarch to nutrient supply management is a central theme in the INSAM program.

Some of the common cropping systems (e.g. rice-based, wheat-based, sugarcane-based and cotton-based) linked to existing all-India coordinated projects and institutional programs will be utilized. The following objectives will be investigated:

(a) Apportioning of the plant nutrient resources to crops in the sequence for obtaining maximum efficiency and turnover of the nutrients for most efficient production;

(b) Quantification of the amount of N fixed by the legumes and the amount absorbed from the soil, is needed. Next the amount removed when the legume is harvested must be deducted to measure net contribution. Companion crops may also benefit while fixation is in progress. The final contribution is to succeeding crops; and

(c) Monitor the cropping system x soil type interaction effect on soil productivity, potential secondary and micronutrient deficiencies and nutrient imbalances in the soil and plant that could have an effect on human and animal health.

Through systems analysis, the quantification of incoming and outgoing fluxes of nutrients among the components of yield, and their effect on total plant yield, will serve to develop some computer simulation models that can be validated over a wider range of environmental conditions. This becomes a challenge which will involve successive approximations. At the outset, the model may focus on a single element, with requirements based on the plant development sequence. This can be enlarged to include the rate of development of effective root volume and estimates of conversion or release rates. All of these are controlled by soil moisture, soil air and temperature. Each additional nutrient element considered in the model will increase the potential equations geometrically.

C. TECHNOLOGY TRANSFER NEEDS AND SUGGESTIONS.

A large quantity of INSAM adaptable technology is available from the all-India coordinated projects, ICAR institutions, national research centers, state agricultural universities and numerous other sources. The concerns expressed by both researchers and extension leaders were how best to: (a) interpret the technology from completed research so that it can be more useable by extension SMS, VLW and the cultivator; (b) extrapolation of the available data so that they can offer solutions to wider range of problems; (c) how best assistance and training of SMSs and VLWs be provided to transfer available INSAM technology into existing and evolving cropping systems; and (d) recruitment of some researchers to assist with the interpretation of the adaptive research and help the SMS and VLW be more effective when working with the cultivator.

1) Some Constraints to Effective Technology Transfer.

To understand how to effectively improve the rate of technolgy transfer from the researcher to the cultivator, it is often necessary to understand some of the constraints that restrict this transfer. The following are some constraints that were commomly listed:

i) Level of education of the extensionist and/or village level worker is not adequate to transfer technology. Cultivators often lack confidence in this person;

ii) Salaries are low and per diem for travel are not adequate and payments are often delayed;

iii) Lack of educational and demonstration materials to effectively carry on technology transfer, educational and demonstration programs;

iv) Poor or almost no direct linkage between the centers of technology development and the education and training of the extension worker;

v) Too many other responsibilities at the VLW level, such as, family planning, seed distribution, census taking, just to mention a few;

vi) Commitments to artificial targets, for example, the need to submit a predetermined number of soil samples to the nearest laboratory regardless of the farmers interest to participate; and

vii) Lack of knowledge of government assistance programs, short term agriculture financial assistance and commodity marketing.

2) Means of Strengthening Technolgy Transfer.

In some of the states visited (Haryana, Uttar Pradesh, Tamil Nadu and Karnataka, in particular) very rapid transfer of technology was observed and all persons with whom the team met were well informed of cropping instensities and potenial for expansion. The team also observed working groups composed of researchers and Department of Agriculture personnel that actively developed technology transfer programs.

The following list covers some means to improve the transfer of current and future improved technology from research stations to the cultivator:

i) Strengthen the training of the extension worker, requireing a minimum M.S. for SMS and B.S. for the VLW who will deliver agriculture technology to the village;

ii) Develop working teams of SMSs that will function together to support the VLWs in transferring the technology of cropping system, INSAM, etc into farming systems for best land use;

iii) Budget and supply sufficient local funds and means to travel among the villages. A large motorcycle would serve nicely to carry some of the necessary materials to many rural villages;

iv) Supply funds and materials to carry on education programs, battery operated slide projector with slides, materials to carry on field demonstrations, just to name some examples;

v) Provide assistance from reseachers to carry on very active in-service training programs to SMSs and VLWs ;

vi) Organize state working groups composed of researchers, extension leaders, soil testing laboratory officers and State Department of Agriculture people who will address the issues of technology transfer systems to the cultivators;

vii) Bring the soil testing laboratories into the main stream of extension education and technology transfer to make use of the latest available soil test calibration information, soil test promotion programs and conducting field validation trials in cultivator fields with the VLWs;

viii) Make full use of the zonal stations being developed under NARP by World Bank as centers where extension workers, industry sales poeple and their agronomists and cultivators can see adaptive research being conducted;

ix) Establish extension agricultural technology transfer audio-visual vans to promote extension education and technology transfer in the more remote rural areas. Establish programs to develop local education materials and keep them current;

x) Interface and feed into programs such Lab to Land, KVKs, T and V, adopt a village, and programs such as the British-Indo Fertilizer Demonstration, as potential multipliers to INSAM; and

xi) Maximize use of modern mass communications systems, i.e. radio and television, whenever possible;

While it is not within the scope of the INSAM project to either resolve the constraints of the reported deficiencies in the delivery system of technology transfer, nor to build a new parallel activity, documentation the of needs is warranted. Some of the deficiencies will require major policy changes, some progressive minor changes and some only cooperation among currently productive programs. Some training in India will be suggested. Some short term observation tours abroad should prove a worthy investment. There is also opportunity to make effective use of a few short term visits by established scientists from the U.S.

D. Equipment Needs and Suggestions

There is considerable scope for enhancement of the effectiveness of this subproject by the judicious provision of equipment. Two criteria are exceedingly important and will have to be addressed as the subproject is implemented rather than at this stage. The first is preparation of an accurate inventory of equipment already on hand, and determination of its adequacy for the assigned task of the unit in which it is located. The second is availability of satisfactory equipment from Indian manufacturers. A third but less critical factor is availability from U.S. sources. This is only less critical because equipment import is not seen as a major element of the subproject.

1. Computers and Data Processing

i) "Basic" Hardware

Information processing, statistical evaluation, collation, reporting and utilization are the areas in which rapid gains can be readily made. Computers, especially microcomputers which are inexpensive enough to be located at the source of data generation, now offer dependable hardware and versatile software to meet almost all the foreseeable needs without significant delay or longterm training of highly specialized personnel. The IBM/PC, XT and AT compatibles produced in India cover the full range of data handling requirements. The data entered on these computers can be transferred to mainframe computers with relative ease and without introducing errors during manual transcription. Summaries or selective data sets can be prepared or extracted without reviewing masses of unwanted data, avoiding the copying errors or errors of omission which are inevitable when manually selecting information from large primary data banks.

ii) Software

Statistical programs for calculating means, correlations, estmation of reliability of data, and display of frequency distribution are all readily available and useable by the soil scientists conducting the research. This assures immediate feedback for modification or design of experiments, and encourages fast release of results through reports and publications. The prepared statistical programs can also help a scientist to avoid some design errors, but not all. Thoughtful use by a well trained scientist is still the only way to good experimentation and result evaluation. If a user-friendly statistical/mathematical system, such as SAS, is not available on a readily accessible mainframe, this should be acquired to enhance the modelling activites.

The word processing capability of the microcomputer should not be ignored. This provides major assistance in report generation. Any person who can type has the abili*· to use one of the many word processing programs. It is not necessary to master any of the other programs available to use the word processor. The only danger is that word processing is so easy and the final product so satifactory that use for this purpose competes directly with the more technical uses.

iii) Special Hardware

Graphics capability is available to assist both interpretation of data and presentation of results for reports and publication. Data entered into either a data base management program or a statistical program can be extracted and plotted directly. A choice of graphic format is available and, with some of the more sophisticated equipment color graphs, can easily be prepared. Data generated on the simplest PC can be transferred to another program and printed in the technicolor format on a compatible computer with the desired capability. Maps can also be prepared from a data base without ever resorting to manual plotting. Although not universally required, programs which control a "mouse" will allow the operator to draw information in the computer for printout at some later time.

The range of printer capability is also exciting. Very rapid printing is available for large data sets. Stylus, laser or dot matrix printers produce graphs and drawings at various speeds and qualities, according to the operator's requirements. Again, graphs prepared and edited on a computer with one printer can be printed in final on another with broader capability, so long as the programs selected are compatible. High quality letter printing is also available for preparing camera ready copy and executive quality correspondence.

iv) Location and Utilization

Microcomputers of appropriate capacity should be installed at the central laboratory, at ICAR institutes, at each of the all-India coordinated program principal offices, at the mother soil testing laboratories in each state, and at the regional sites for soil test evaluation and longterm fertility experiments. It will also be profitable to make the same computers and software available to the soil and/or agronomy departments at the agricultural universities in each state. Research and service organizations working on soils and plant nutrient management could also make good use of the same or compatible equipment.

The pace of procurement will depend on the availabilty of funds. It is not necessary for all potential users to receive the equipment at the same time. It will even be advantageous if a few computers are installed in some of the more critical locations to test the suitability of the programs available and determine the time required to train a cadre of operators proficient in their use. From this experience more realistic plans for procurement of equipment and for its utilization can be prepared.

2. Research Equipment.

i) Field Equipment.

The essential data for rational plant nutrient management must be generated in the field and laboratory. There is little that this project can contribute to the equipment required for field research except to note that the lack of transportation for staff and supplies often limits the amount of research which can be done and the reliability of that which is done. The assessment of field plot research equipment requirements, based on a fresh inventory must be completed early in the subproject. The institutions that will contribute to the INSAM must be adequately equipped to conduct viable field research. When verification experiments are carried to farmers' fields, adequate transport becomes expecially vital.

iii) Laboratory equipment

Such basic equipment for the laboratory as pH meters, conductivity meters, flame photometers, colorimeters and shakers, are all avaiable from Indian manufacturers.

With mounting evidence that micronutrients are becoming the limiting factor in crop production, equipment is needed to determine their levels in soils and plants quickly and accurately. In most cases an atomic absorption spectrophotometer is the instrument of choice. The brand and model should be chosen for reliability and ease fo maintenance, as long as it gives acceptably accurate readings. One AA spectrophotometer should be available in each mother soil testing laboratory and the new central facility, but certainly not initially at the district level .

An ICP emission spectrophotometer may be warranted for the newly created soil science research center, but careful analysis of the need, the cost, operating and maintenance problems must be undertaken before it is ordered. Buying should wait until the new building is completed and a fully climate controlled laboratory is available for installation.

A mass spectrometer can be a very valuable research tool, but is exhorbitantly expensive and its purchase might seriously impede progress in this project by tying up very scarce funds. The electro-ultra-filtration unit, such as employed by the Potash Research Institute of India, may lead us to a better understanding of the potash supplying power of soils, but is not well adapted to extraction of a large number of samples. It has not found general favor in the U.S., although one laboratory has been using an extraction based on the same general principle for over thirty years. If this equipment is desired by the scientists at the new central laboratory, funds for purchasing it should come from another project.

3. Extension Equipment

SMSs in the soil science or soil science-agronomy units need simple but dependable slide projectors and monies to support the development (film, processing, mounts) of a limited number of slide sets such as: (a) depicting proper fertilizer application methods; (b) characteristics of readily available fertilizers; (c) nutrient deficiency systems; (d) tillage and residue management systems; (e) organic sources of nutrients; (f) proper soil sampling procedures; (g) soil analysis report interpretation, etc. In selected states, liming principles and or alkali soil reclamation practices should be stressed. These slide sets could be used repeatedly, especially, if they emphasize primary principles of crop and soil management and, therefore, could be used for many years.

Furthermore, some funds should be allocated for purchase, where appropriate, of prepared slides (or complete sets) from organizations such as the Fertilizer Association of India (FAI), IRRI, ICRISAT, Phosphate-Potash Institute of USA, the Fertilizer Institute (USA), TVA and IFDC, that would be applicable to Indian agriculture.

A limited number of overhead transparency projectors and supplies are needed for the workshops and annual meetings convened by the all-India coordinated project coordinators. These should be given to and be the responsibility of the coordinator. These projectors lend themselves to forums, workshops, group discussions, seminars, planning meetings (especially where darkening the room is difficult, and it is desirable to face the audience). This same equipment (now designed and produced to be carried in a portable case) can be moved conveniently and shared by resident professors and administrators.

Great care should be given to use of this machine as an "aid" to presentation of ideas and information. Transparencies can easily become very cluttered with words that can't be clearly followed. Not more than 2 - 3 ideas or bits of information should be presented on each transparency. Use pens that contain water soluble ink so that the inevitable clutter that develops can be quickly and easily wiped off.

Recorders, tapes and operating monies should be supplied to develop and duplicate tapes for use by All-India Radio stations. The subjects which these tapes address should be direct, straight forward directions for proper use of fertilizers for multiple cropping systems, up-to-date crop production technology and other matters of soil tillage, soil and water conservation, residue management, proper use of green manure, cover crops and pest protection.

Audio-visual equipment will be essential for preparing educational programs for televison and for use by extension workers at various levels. Again, no inventory of such equipment is available. It is understood that the additional equipment needed can be purchase in the local market.

E. Training Requirements and Suggestions

1. Training in India

i) Computer literacy and data processing

There are few if any countries in the world with a scientific manpower pool equal to India's. Most training required for INSAM will be of highly specialized nature to help skilled research and service officers acquire unfamiliar techniques most efficiently. In most cases, such training can be provided in India by Indian scientists and engineers. Computer use skills are a typical example. These have not been in the basic curriculum of the majority of established research officers and university professors, and yet they can be an almost invaluable asset. Even those in administrative positions will find a basic knowledge of computer capability a help in planning and resource allocation. The depth of training and the range of skills will depend on the job to be done by the individual. Broad training for most potential users is desirable. Training of an exclusive cadre of computer specialists should be avoided. This practices isolates the scientists who generate the data from its analysis, evaluation and interpretation.

ii) Soil testing laboratory operations.

Programs for training and strengthening the skills of directors and chemists in the soil testing laboratories were described to the team participants visiting various institutions in India. This program might be strengthened further by workshops focussed on laboratory management, soil test utilization and interpretation, especially if these workshops were convened at one of the more successful laboratories in the country. A university laboratory can provide basic training and demonstrate specialized skills but cannot recreate the atmosphere of a large service laboratory. Exchange of personnel may also be a useful means of training. Working beside or under the daily guidance of a highly skilled analyst, or sharing the writing of soil management recommendations with a very experienced agronomist, can provide many insights not available in textbooks, manuals or even the latest journal publications.

iii) Extension Specialists

University crop and soils extension specialists and key SMSs of the Department of Agriculture should be allocated funds to travel to and participate in regional workshops (each individual attends one every third year) at a selected university or appropriate research institute. The location should be within major agro-climatic zones. One conference could be held each year, rotating between (1) northeastern or eastern India (2) one in southern or south-central India and (3) one in north-north central India. Reports of "packages of technology", effective field demonstration procedures, successful visual aids, and other successful educational program should be highlighted in oral reports to other specialists at the workshop. Problems of mutual concern should be discussed and solutions suggested.

Research should be reviewed by the particpants and interaction with appropriate scientists encouraged. This kind of an assemblage of SMSs is an uplifting and morale building experience. It is particularly useful to new, young and inexperienced personnel. The interaction of these persons will stimulate the development of new ideas and challenges them to try new methods in helping village cultivators understand the role and value of proper use of fertilizers for increased income.

The workshop should always provide presentations by "communications" specialists (persons who know how to pass on and present information in a more understandable manner). Presentations should emphasize:

1) How to write simple straight forward concise, logically organized ideas in newspaper and magazine articles.

2) How to prepare high quality, short and to the point radio tapes.

3) How to take pictures for top quality slides.

4) How to make visible, uncluttered logical charts and posters.

5) How to write improved but inexpensive leaflets.

6) How to make the most of field strip demonstrations, that is, labeling of plots, field layout, strategic location near the villages, value of a field meeting at the field site.

7) How to choose suitable materials and best methods to use for labeling field demonstration strips.

8) The need to invite, occasionally, a representative of a good local newspaper, radio-station or a private graphics specialist to highlight successful communication technology.

The new soils center might undertake development of a quarterly news letter. It should help keep attention on the need for relevant research. It should contain discussions about successful methods (field demonstrations, training sessions, radio tapes, field and village meetings, successful soil sampling campaigns) that highlight effective methods of imparting soil management and crop production technology. This newsletter should be widely circulated. It should go to extension specialists (and most educators of farmers) in all agencies, i.e. Departments of Agriculture, research institutes, universities as well as key persons in the fertilizer and seed industry.

At either the specialists' workshop or in the newsletter, time or space should be given to elaborate upon how, where and what is done to produce high quality fertilizer, seed, and crop protection chemicals. Logistics of procuring supplies and timing for adequate delivery could be addressed and elaborated upon. Representatives of industry would become better known by the extension specialists. Both extension specialists and industry representatives could struggle with the resolution of mutual problems. The same kind of help could be asked for from key representatives of the banking industry (those concerned about agricultural production and village improvement).

2. Training Abroad

Training abroad still has a valid place in the program, but the type of training must be designed to match the knowledge and skills of the Indian participants. As indicated, Indian professionals already have the basic training and skills required for this program. Exposure to somewhat different management and organizational styles and systems may be very stimulating. Observation tours, particpation in workshops and seminars or actually working for a period of four to six months may be the types of "training" which will be most useful.

i) Soil testing laboratory management

The observation tours must be focussed on specific themes to be most productive. For example, service laboratory management is one logical theme. Under this would be first a definition of the goal or purpose of the laboratory. Samples accepted should constructively contribute to the goal of the unit. Frequently service laboratories are swamped with samples that have little or no value. Next, specification of sampling technique and background information is required for each sample. The processing of the sample must be planned both physically and organizationally for efficiency. Contamination and loss of identification can cause serious problems. The accuracy of analyses must be assured by the use of standard samples at reasonable frequency. Instruments must be adjusted and calibrated often enough to keep errors within acceptable limits. At each point of measurement a permanent record must be made and the same information passed to some central point where the consilodated report is made, interpreted and from which specific recommendations may be made.

There will be a wide range of physical and organizational practices to achieve the purposes outlined. The purpose of an observational tour would be to provide exposure to a good sampling of laboratories so that the participants might judge what would be desirable and what could be practically implemented in their own laboratories.

ii) Extension methods

A similar tour might be useful for supervising extension officers or extension specialists in soil and crop management. Their tour might focus on obtaining and utilizing research information, especially the interactions between extension officers and those conducting the research on soils and plant nutrient management. It might concentrate on interactions among extension personnel and how sharing programs and experience strenghtens program. A third theme might be interaction with farmers, the role of assistants and subordinates.

Industry plays a major role is extension in the U.S. A tour which highlighted the interaction of research at federal, state and university level with the industry from primary manufacturers to retail salesmen, might provide a different perspective on the relationships or potential relationships. At the adminstrative level, directors of research and directors of extension in the state departments of agriculture could find a tour which examined various patterns of organization and practices in states in the U.S. would give them useful insights into their own organizations. Tours which included an opportunity to observe working sessions for planning programs or organizing campaigns should also prove valuable.

It would be most desirable for approximately 6 - 8 relatively young productive agronomists (soils and crop specialists) to participate in a four week study tour to about six U.S. land-grant universities to view how U.S. extension crops and soils specialists perform. The U.S. schedule could probably be developed by the U.S. Department of Agriculture, and Federal Extension Service agronomists. One U.S. specialist should accompany the Indian team. Not only would they see the successes but the weaknesses that still exist in the U.S. extension agronomists' attempts at transferring technologies.

Early at each site visit one of the Indian participants should explain how extension specialists conduct their job. He should explain how he links up with extension workers in the state department of agriculture, soil testing personnel, the seed industry and fertilizer industry. With this backgound the U.S. extension agronomists can relate their remarks and experience to the constraints (movies, land, education, distance, etc.) that face the Indian extension agronomists. From this study tour, many ideas and new viewpoints will be formulated. The Indian agronomist will also realize that the U.S. agronomist still has a lot of work to do. This effort would greatly boost the morale and also provide recognition of key Indian extension subject matter specialists.

These men, upon return and at the earliest opportunity, could communicate these ideas and offer suggestions to associates at their own university as well as through the regional workshops and numerous articles in the proposed newsletter. The U.S. study tour may uncover additional educational materials, i.e., publications, slide sets, radio tapes, etc. that could be adapted to crop production and soil management systems in India.

If timing can be conveniently arranged, tours should include participation in the meeting of one of the professional societies, especially the American Society of Agronomy and the Soil Science Society of America. One of the regional meetings could provide a quite different perspective than the somewhat overwhelming annual national meeting.

iii) Specialized participant observations

The workshop is another useful format for "training" abroad. In this the Indian participant would be expected to present a paper about his own research, methodology or organization and discuss it with American colleagues in the same manner as they present and discuss their own. Such participation could provide an opportunity to strengthen the design of a new research effort or to gain addditional insights into data already on hand. Workshops on the use of new statistical designs for experiments or on crop modelling are examples. A comparison of experience on computer software is another.

iv) Professional interchange

The third category of training is the active participation. There are a number of situations in which an Indian scientist or extension specialist might replace and American. The easiest example would be as a chemist in a laboratory or a microbioligist working on a problem associated with biological nitrogen fixation. Where it is not feasible for the Indian to be an actual replacement, he might be a constant companion of his American counterpart.

A variation on this theme is a joint endeavor in which a project directly related to Indian research and development is carried out by a team of Indians and Americans partly in India and partly in the U.S. While training is involved, a very tangible and useful product may also be obtained. A proposal by Dr. Bohlool of the University of Hawaii to produce an informative TV documentary about biological N fixation research and utilization in the U.S. and India is a good example. This will not introduce any new concepts but the interaction of the two groups should produce a program which will be more exciting than either could do alone.

Another area for a cooperative effort is in the crop systems modelling. Although elements of training in the U.S. will be helpful, the Indian scientist involved will be bringing much of the critical data to extend the range of the models and thus contribute materially. The U.S. participants are the most logical consultants to come to India and work with the same core group of Indian modellers. Project design and statistics may well be included, since much old data do not always provide all the information required for the model.

F. Consultancy Needs and Suggestions

1. Indian Scientists

Consultants should be sought within India. A very competent consultant on computer hardware and programming was interviewed by the U.S. team members. The team was also told about the CMSC corporation, which will provide continued technical support on computer utilization for a modest fee. Retired professors and government officers possess a wealth of experience and knowledge which should be tapped. Some companies are capable of providing excellent advice, but this may be somewhat biased according to their own product line or that of close business associates. Within universities, other departments are likely to have professors who can be very helpful to the INSAM program if they are adequately compensated for the time lost in pursuing their own professional field.

It is suggested that a recognized "visual aids" production specialist from one of the agricultural university departments be employed as a consultant for fo r to six weeks, to lead two to three day workshops in strategic locations . Such a person could demonstrate and help research and extesnion workers to prepare different kinds of adult educational aids. Particular emphasis should be given to the preparation of 2X2 slides and timely and punctual tapes for radio broadcast.

2. U.S. Scientists

Two classes of U.S. specialists may be helpful to reaching the goal of a successful program in integrated plant nutrient management which extends from the basic soil and plant physiology laboratories to farmers' fields. The most obvious is the acknowledged technical specialist. The second is an administrator, scientist or extensionist actively or recently engaged in a comparable function in the U.S. who might share his knowledge, skill and experience with his Indian peers. Perspective can be extremely useful in any enterprise. A visitor may see things, which the person working on the problem day to day will miss because it is so normal. As often the process of explaining a situation or problem to a visitor, even a naive one, will give an insight not previously gained through hard analysis. A consultant who joins in the attack on a program can be much more useful than one who limits his contribution to advice.

The following may be opportunities and means to gain the most from consultants from abroad:

i) The computer field is changing daily and scientists developing programs but more particularly those applying programs in conducting their research can be very helpful. One of their chief roles should to describe the limitations of highly touted, even widely used software in data base management, statisitcs and report preparation. One consultant who might prove very useful is a specialist in mapping by computer and computer graphics.

ii) An extensionist with a successful record in videotape production could suggest ways that will make programs more useful for teaching soil and crop management skills to different audiences, from university students, to secondary school and primary school students and ultimately to farmers unable to read or write. Such material has a great advantage, the sound can be dubbed in so that each farmer hears the message in his own language. If a pre-recorded sound track is not available in that language a local extensionist can provide the commentary as the tape is displayed on the "tube".

iii) The director of a service laboratory may be able to make a few suggestions during a tour which will materially increase the output of a soil testing laboratory. For example, he may be able to identify a whole class of samples for which the full range of analyses is totally unnecessary, freeing analysts to work on the more pressing samples. On the other hand, he may suggest studies to be carried out in slack seasons which will provide useful information to the laboratory or to the associated agronomist.

iv) The potential of crop models as a guide to research and to improve recommndations for crop management where complete data are lacking is an exciting facet of agronomy at present. A consultant or better a scientific cooperator to take part in a workshop, seminar or to assist in model modification and testing for major crops could prove most useful. In this case repeated contacts over the life of the subproject will prove more useful than a single protracted stay. It might also be preferable to have several consultants, since crop modellers seem to specialize by crop.

v) A sticky problem in using available data is making profitable use of soil taxomony. A series of regional seminars presented by a specialist in agronomic and fertility intepretation of the U.S. and F.A.O. classification systems could help substantially to improve crop management recommendations.

vi) Defining when rhizobia are effective sometimes and not in others might depend on proper identification of the infecting bacteria. An expert in rhizobium taxonomy might lead one or more seminars on tracing inoculant strains through a normal crop sequence. This consultant should also spend some time actively working in a host laboratory to demonstrate the techniques he describes.

vii) There is an urgent need to dispose of and to utilize municipal waste, but realistic analyses of the costs and to whom which benefits accrue seem to be lacking everywhere. A consultant who could work with Indian agronomists, engineers, microbiologists and economists to develop an understandable model of the system and a valid estimate of the costs would help to make plans which are achievable and goals that are reasonable. It must be someone who understands that farms are being used as a disposal point for unwanted waste, that sorting and composting are required steps to make the bulk product acceptable, and that the final product has a low plant nutrient content which severely limits the area over which it may be used profitably.

viii) A somewhat similar analysis should be conducted for the inclusion of legumes and other organics which contribute to the biological fixation of N. Proponents of BNF seldom treat the cost of land occupancy, labor, or accessibility of all requisites in their arguments for its utility. Doubters often see the costs to the almost complete exclusion of all else, including benefits other than the N which a legume in rotation or as a cover crop may contribute.

A consultant on the analysis of the potential contribution of biological N fixation to the farmer and to the nation could provide a document useful for setting goals for achievement of BNF targets and setting complementary goals for what must be provided by fertilizer and its more efficient use.

ix) The new soil research center is going to require a major capital investment and a generous sustaining budget. Planning both the disciplinary commitments and the physical plant to carry out those commitments will be a difficult task. While those who will eventually man the institution should have a very large voice in its creation, ICAR has to look at the cost and how the new unit fits within the national priorities. An independent consultant or consultants who have no vested interest in the final outcome could prove invaluable in laying a limited number of viable alternatives. No consultant can make the final decision on which alternative best meets India's needs.

x) Coordination of the various programs to be included under the integrated nutrient management umbrella is going to be a major challenge. A management consultant well versed in implementation of collaborative projects rather than line of authority organizations should prove invaluable.

APPENDIX A

All-India Coordinated Program Centers.

APPENDIX A: ALL INDIA COORDINATED PROGRAM CENTERS

I. All India Coordinated Research Project for Investigations on Soil Test Crop Response Correlation

1. Coordinating cell, CRIDA, Hyderabad (AP)
2. JARI, Barrackpore (WB)
3. UAS, Bangalore (Karnataka)
4. TNAU, Coimbatore (TN)
5. RAU, Dholi (Bihar)
6. HAU, Hissar (Haryana)
7. JNKVV, Jabalpur (MP)
8. PAU, Ludhiana (Punjab)
9. IARI, New Delhi
10. HPKVV, Palampur (HP)
11. GBPUAT, Pantnagar (UP)
12. MPKVV, Rahuri (Maharashtra)
13. JNKVV, Raipur (MP)
14. APAU, Hyderbad (AP)
15. Department of Agriculture, Calcutta (WB)

II. All India Coordinated Research Project on Long Term Fertiliser Experiments

1. Coordinating cell, IARI, New Delhi
2. G.B.P.U.A.T., Pantnagar (UP)
3. JNKVV, Jabalpur (MP)
4. A.P.A.U., Hyderabad (AP)
5. OUAT, Bhubaneswar (Orissa)
6. HPKVV, Palampur (HP)
7. PAU, Ludhiana (Punjab)
8. UAS, Bangalore (Karnataka)
9. TNAV, Coimbatore (TN)
10. BAU, Ranchi (Bihar)
11. IARI, New Delhi
12. JARI, Barrackpore (WB)

III. All India Coordinated Agronomic Research Project

1. Coordinating Cell, UAS, Bangalore

Main Centers

2. APAU, Hyderabad
3. AAU, Jorhat (Assam)
4. BAU, Ranchi (Bihar)
5. GAU, S.K. Nagar (Gujarat)
6. HAU, Hissar (Haryana)
7. HPKVV, Palampur (HP)
8. SKUAS, R.S. Pura
9. UAS, Honnaville (Karnataka)
10. KAU, Karamana (Kerala)

11. JNKVU, Jabalpur (MP)
12. PKV, Akola (Maharashtra)
13. KAV, Parbhani (Maharashtra)
14. MPKV, Rahuri (Maharashtra)
15. OUAT, Bhubaneswar (Orissa)
16. PAU, Ludhiana (Punjab)
17. MSUA&T, Jaipur (Rajasthan)
18. TNAU, Coimbatore (TN)
19. NDUAT, Faizabad (UP)
20. CAUAT, Kanpur (UP)
21. GBPUAT, Pantnagar (UP)
22. Maruteru (AP)
23. Rudrur (AP)
24. Pusa (Bihar)
25. Junagadh (Gujarat)
26. Navsari (Gujarat)
27. Bagatisheroo (J&K)
28. Sirupuppa (Karnataka)
29. Indore (MP)
30. Rewa (MP)
31. Sehore (MP)
32. Raipur (MP)
33. Karjat (Maharashtra)
34. Manipur (Manipur)
35. Chiploma (Orissa)
36. Banswara (Rajasthan)
37. Thanjavur (TN)
38. Bichpuri (UP)
39. Varanasi (UP)
40. Kalyani (WB)
41. Kharagpur (WB)

IV. <u>All India Coordinated Research Project for Dryland Agriculture</u>

1. Coordinating cell, CRIDA, Hyderabad (AP)

<u>Main Centers</u>

2. HAU, Hissar
3. UAS, Bangalore
4. APAU, Hyderabad
5. GAU, Rajkot
6. PKV, Akola
7. MPKV, Rahuri
8. TNAU, Kovilpatti
9. JNKVV, Indore
10. OUAT, Bhubaneswar
11. BAU, Ranchi
12. BHU, Varanasi

Sub-Centers

13. GAU, Dantiwada
14. JNKVV, Rewa
15. PAU, Ludhiana
16. MLSU, Udaipur
17. UAS, Bijapur
18. SKUAT, Rakh Dhiansar
19. RBS College, Agra
20. NDUA&T, Faisabad

V.. All India Coordinated Research Project on Micronutrients in Soils and Plants

1. Coordinating cell, PAU, Ludhiana
2. Lucknow University, Lucknow (UP)
3. HAU, Hissar (Haryana)
4. PAU, Ludhiana (Punjab)
5. JLNKVV, Jabalpur (MP)
6. RAU, Dholi (Bihar)
7. APAU, Hyderabad (AP)
8. GAU, Anand Campus (Gujarat)
9. TNAU, Coimbatore (TN)
10. IARI, New Delhi

VI. All India Coordinated Research Project on Microbial Decomposition and Recycling of Organic Wastes

1. Coordinating cell, Palampur (HP)
2. HAU, Hissar (Haryana)
3. UAS, Bangalore (Karnataka)
4. MPKVV, Pune (Maharashtra)
5. BAU, Ranchi (Bihar)
6. BCKVV, Kalyani (WB)
7. CAUAT, Kanpur (UP)
8. IARI, New Delhi
9. CPCRI, Kasargod (Kerala)

APPENDIX B

Soil Testing Laboratories.

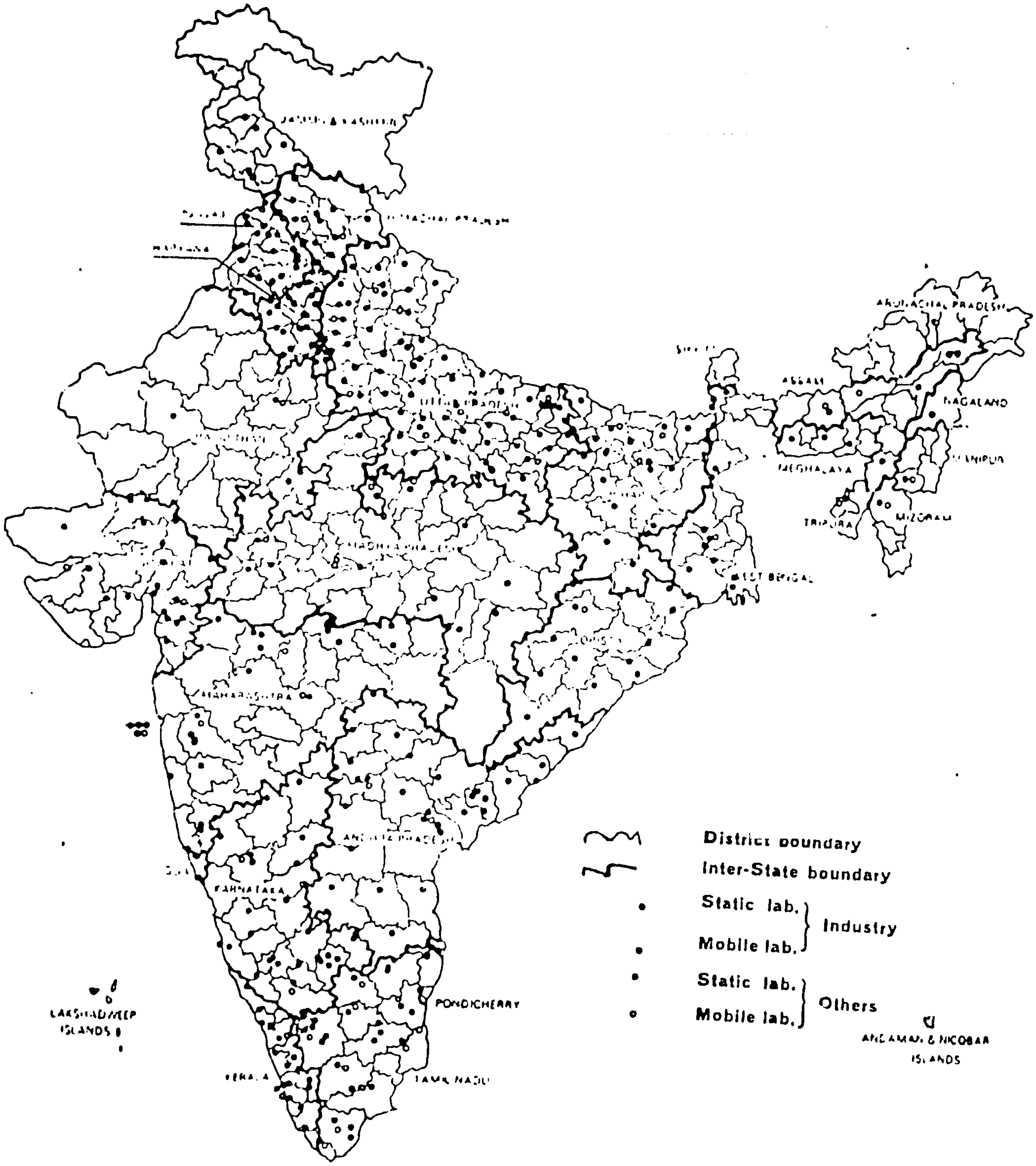
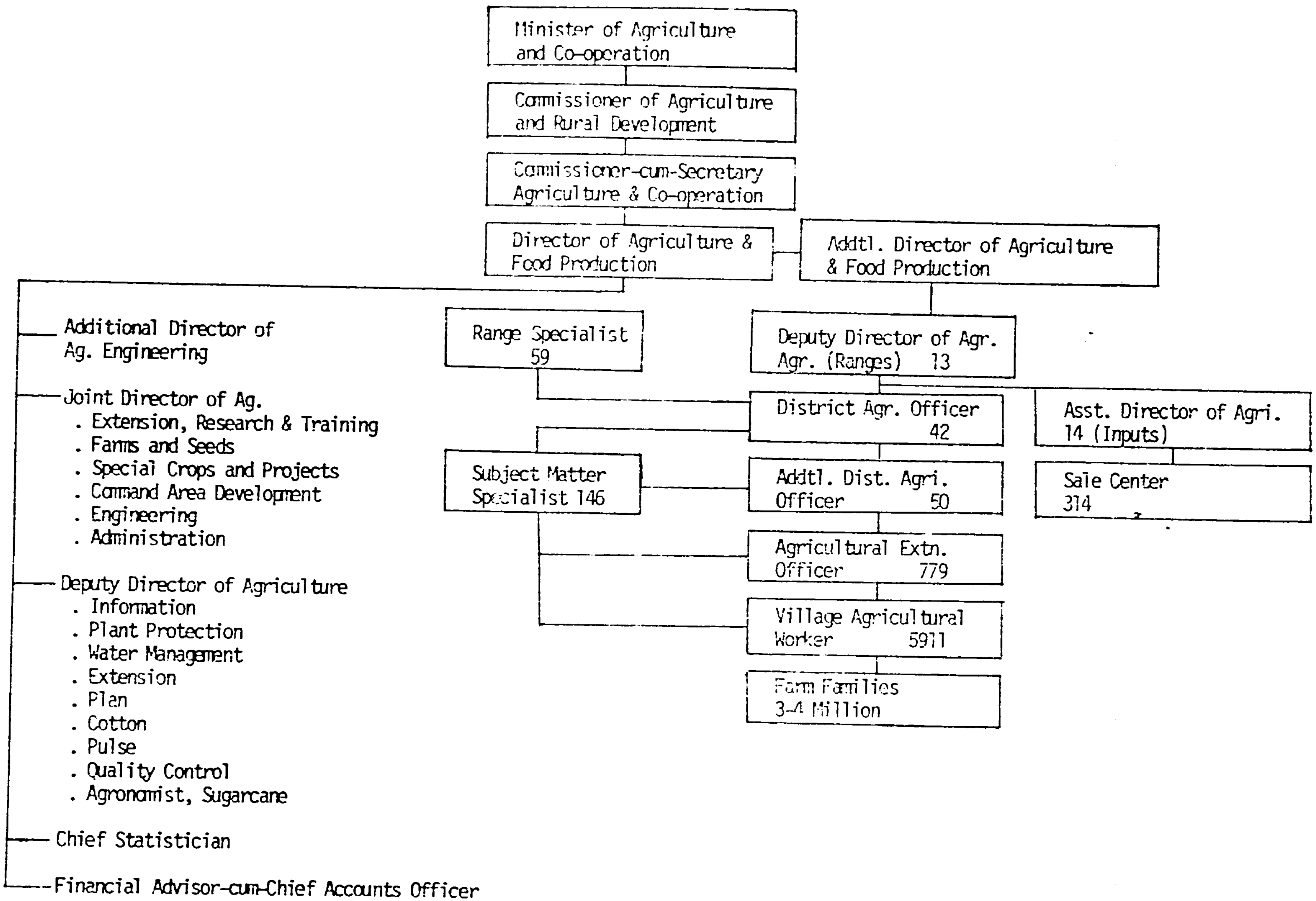


Figure 1.1 *Location of 402 soil testing laboratories in India. The labs vary greatly in size, i.e., 45 labs in U.P. have a capacity of 1-2 thousand samples/year while many labs in Tamil Nadu have capacities of over 30,000 (Map designed by ENSP)*

APPENDIX C

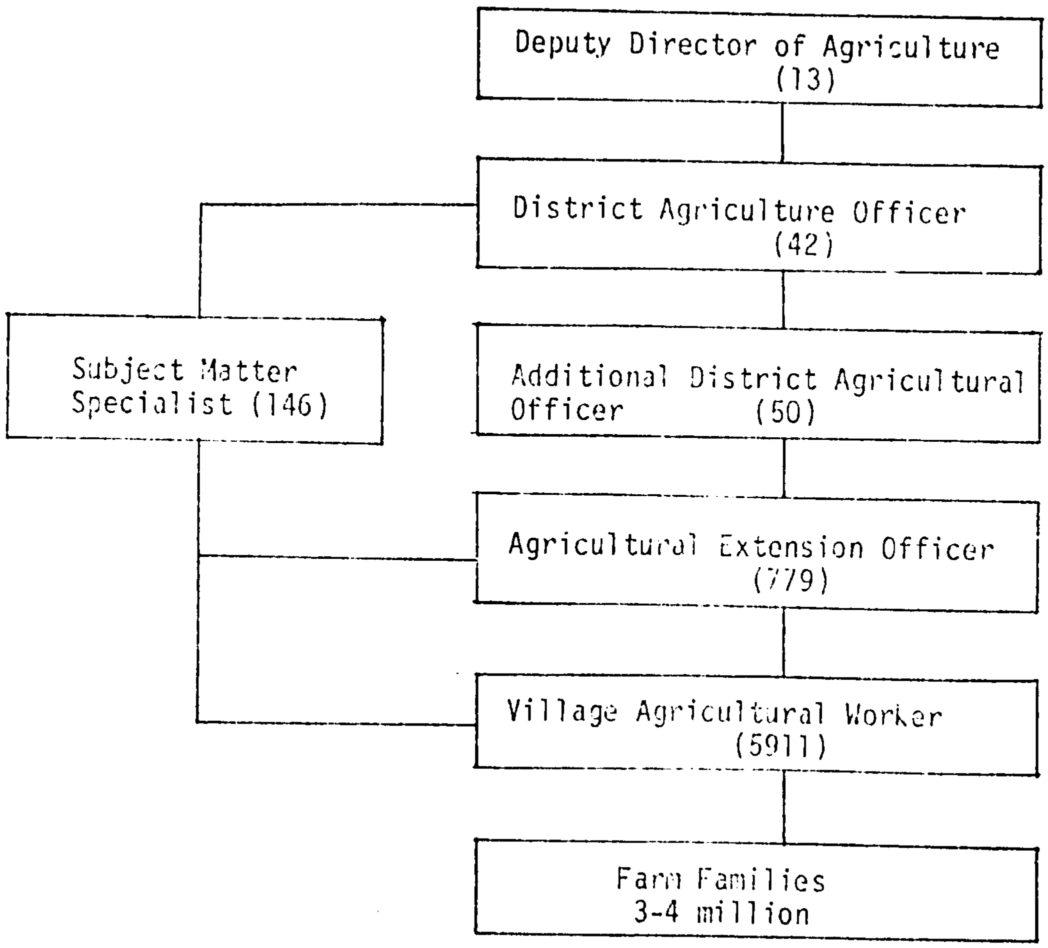
Eextension Organization Structure
Figures 1 & 2.

FIGURE 1: PRESENT ORGANIZATION OF AGRICULTURAL EXTENSION



Example: Orissa

FIGURE 2: TECHNOLOGY TRANSFER FROM SUBJECT MATTER SPECIALIST TO FARM FAMILY



Example: Orissa

APPENDIX D

Suggested Organizational Structures
Figures 3, 4, 5 and 6.

FIGURE 3: COMPONENTS OF INTEGRATED NUTRIENT SUPPLY AND MANAGEMENT (INSAM)

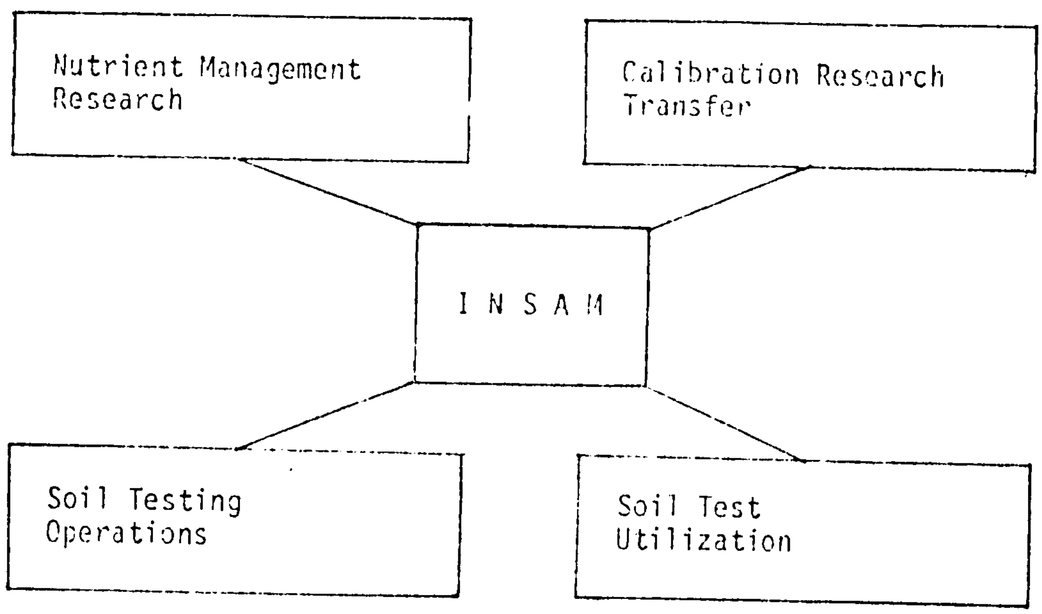


FIGURE 4: FUNCTIONAL ORGANIZATION NETWORK
OF INTEGRATED NUTRIENT SUPPLY & MANAGEMENT (SAM)

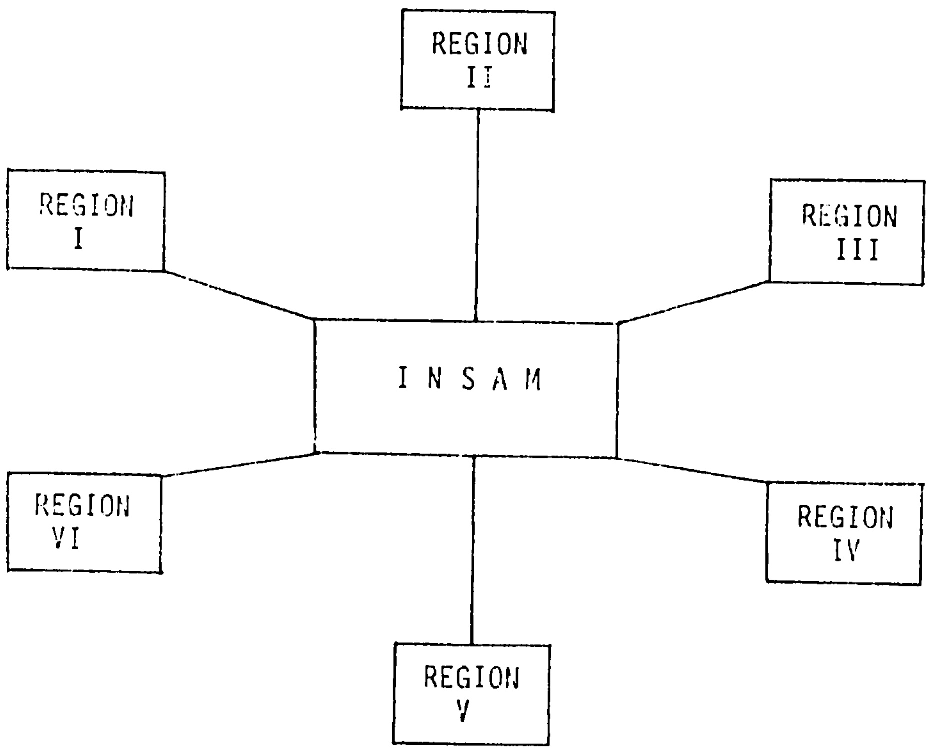


FIGURE 5: CONFIGURATION OF A REGION

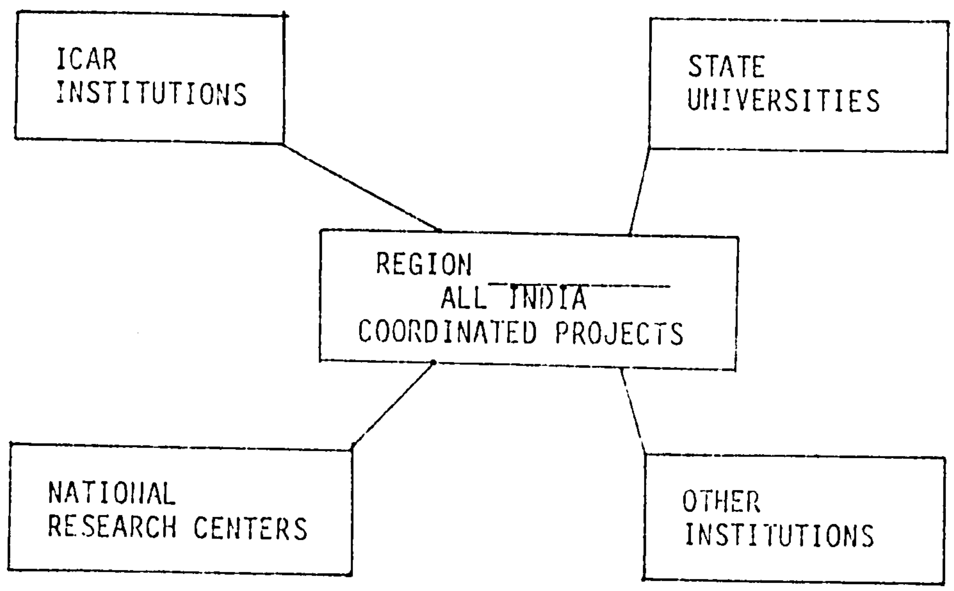
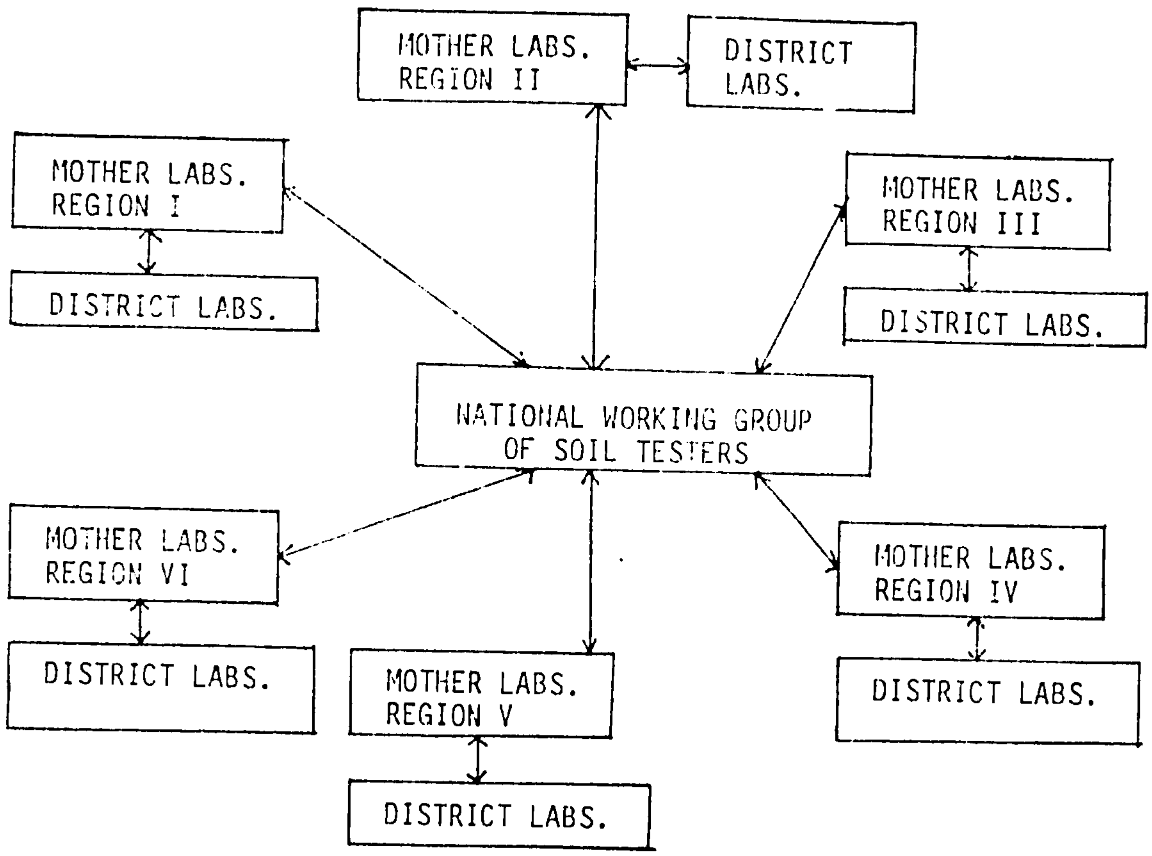


FIGURE 6: NATIONAL SOIL TESTING COORDINATED TECHNOLOGY INTEGRATION TRANSFER ORGANIZATION



APPENDIX E

TABLE 1. Suggestions for Research Inventory Workshops.

TABLE 1. Suggested Subjects for the Organization of Workshops to Inventory Research, by Regions, as this Relates to INSAM. Phase One.

I. **Major Systems to Consider in Research Inventory.**

A. Major crops and cropping systems.
B. Major soil-climate associations.

II. Plant Nutrition Reseach Inventories.

A. Nitrogen response and economic returns.
B. Phosphorus and potassium Soil test calibrations.
C. Sodic and saline problems, quantity and effectiveness of amendments.
D. Acid soil problems, calibration of lime and/or alternative amendment requirements, economic evaluations.
E. Soil-Plant micronutrient calibration, identified problem systems, economics of treatment.
F. Nutient concentrations from alternative sources, such as; manures, composts, organic residues, blue-green algae, azolla, green manures, azospirilum, legume intercropping and residual following legumes.
G. Nutrient inputs-outputs simulation of cropping systems as this relates to changes or does not change; soil salinity, acidity, phosphorus, potassium and relative soil productivity.

III. Expected Workshop Outputs.

A. Complete an inventory of INSAM necessary research as this addresses sections I and II.
B. Acceptance or suggestions for changes in soil testing procedures as these are addressed in sections I and II.
C. Development of new, or reconfirming, of guidelines to interpret soil-test values into fertilizer recommendations as they address sections I and II.
D. Establishing of nitrogen, phosphorus and potassium response curves, addressing sections I and II, so that recommendations adjustments can be provided to cultivators with limited income, so they can best maximize their return.
E. Determine what are, and assess the long term land value added soil treatments or reclamation practices vs immediate impact return treatments and the economic viability of each.

APPENDIX F

TABLE 2. Research Priority Planning Methodology.

TABLE 2. Suggestions for Regional Research Priority Planning Methodology.
Phase Two.

I. Scale for selection of crops, cropping systems and soil associations of importance to state and/or region.

A. Selection of crops. (agronomist will list).
5-Major crop or high value crop grown in State or Region.
4-Major crop or high value crop grown in some districts of State or region, or potenially new economic crop.
3-Crop has some pockets of concentration.
2-Crop of low input or low income potential.
1-Crop of little interest, or some grown for personal comsumption.

B. Cropping System (Agronomist will list).
5- Dominate system in state or region.
4- Major system in some districts of state or region, or newly emerging cropping system.
3-System of major importance as concentrated pockets.
2-System used only in widely scattered areas.
1-System not or seldonly seen or used in state or region.

C. Soil associations (soil scientist will list)
5-Most dominate soil association in state or region.
4-Most dominate soil association in some of the districts in the state or region.
3-Pockets in some districts where this is a common soil association.
2-Soil association not suited for food crop production.
1-Forest or waste land.

II. Identification of areas of research.

A. Major INSAM research inputs needed (participating scientist will develop).
5-Of highest priority in state or region.
4-Need commonly found in some districts within state or region.
3-Pockets where this is a need in some districts within state or region.
2-Of minor importance in state or region.
1-Problem or need not known to exist in State or Region.

III. State-of-the-art of present research knowledge.

A. Level of available knowledge of the areas of research listed in II. A. (To be scored by participating scientist).
5-Little is know about the subject.
4- Some research underway, new emerging area of interest.
3-Strong programs underway, some refinement needed; research has wide range of adaptability; can be concentrated in some key locations.
2-Much information is available, data needs interpretion and made avaialble for use.
1-Subject is mature or not important in state or region; no new research is needed; might think about phase down or out.

IV. How to use the system?

A. Step One: Have the researchers input to sections I., A, B and C. Have these scored from 1 through 5. Then multiply A and B by C in section I to identify crops, cropping systems and soil associations of major importance in the respective states and/or regions.

B. Step Two: Have the areas of research important to INSAM (as prepared for section II), scored from 1 through 5 using criteria of section II. A above.

C. Step Three: Have the researchers score the list prepared for section II (areas of research) by the level of available knowledge or state-of-the-art scoring method presented in section III. Multiply the scores from IV B by IV C to obtain a relative need or major research information gap necessity of INSAM. This should identify the major and minor gaps in knowledge. This system or method is completly open-ended because items can be added, deleted or modified from the list or system. One can then mutliply these scores back against section I, to look at how this will interfaces with crop, cropping systems and soil associations.

APPENDIX G

Suggested Budget.

INSAM - TENTATIVE DOLLAR BUDGET

ITEM	UNIT COST	NUMBER	TOTAL COST
EQUIPMENT			
Atomic absorption spectro-photometer	$ 20,000	15	$ 300,000
ICP emission spectrophotometer	150,000	1	150,000
Computer software per set	2,000	15	30,000
Audio/visual material per set	1,500	10	15,000
Subtotal			$ 495,000
TRAINING			
Fees	$ 5,000	149 mos.	$ 745,000
Per Diem	2,250	149	335,000
Transportation	3,000	146 trips	438,000
Subtotal			$ 1,518,250
CONSULTANCY			
Fees per month	$ 6,000	46.5 mos.	$ 279,000
Per diem per month	2,400	46.5	111,600
Transportation	3,000	32.0 trips	96,000
Subtotal			$ 486,600
GRAND TOTAL			**$ 2,499,850**

INSAM - TIME BUDGET

FIELD	DURATION (months)	PERSONS (number)	PERSON MONTHS
TRAINING			
Laboratory management	1	30	30
Extension agronomy/soils	1	60	60
Research Planning and statistics	1	50	50
Senior program management	1.5	6	9
Total		146	149
CONSULTANCY			
Computer software	1.5	5	7.5
Audio/visual for extension	1	4	4
Laboratory management	1.5	2	3
Crop modelling	1	8	8
Interpretive soil taxonomy	1	2	2
Microbiology - Rhizobium	1.5	4	6
Legume systems economics	1	2	2
Engineering economics - composting	2	2	4
Research facility planning	8	1	8
Management/Systems analysis	1	2	2
TOTAL		32	46.5