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SOIL FERTILITY IN BANGLADESH

A CONSULTANCY REPORT

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SOIL FERTILITY IN BANGLADESH

Consultancy Report

by

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THE AUTHOR

Dr. Sam Portch received his Bachelors and Masters degrees from Macdonald College of McGill University in Montreal, and his Ph.D. from the University of Arkansas in the USA. All degrees were in the area of Agronomy - Soil Science.

Dr. Portch has had 20 years experience in the area of soil fertility research and program development. His experience includes positions as Project Field Supervisor for Macdonald College Soil Fertility Trials; Research Assistant at the Soil Testing and Research laboratory at the University of Arkansas with responsibilities in service laboratory operation, and laboratory and field research; Regional Director for Panama and Ecuador for the International Soil Fertility Evaluation and Improvement project of North Carolina State University, where he developed high capacity laboratories and established soil fertility evaluation programs, Soil Fertility Consultant to the Government of Ecuador for five years, and Soil Conservation and Management Consultant with Agro - Science Environmental Institute and International Agricultural Development Service in Ecuador until the present.

Dr. Portch is a member of the American Soil Science Society, the American Society of Agronomy, and the Ecuadorian Soil Science Society. He was honored by this later society being awarded the first lifetime membership in recognition for his services to the Ecuadorian society.

Dr. Portch's international experiences include working in Guatemala, Costa Rica, Panama, Ecuador, Venezuela, Dominican Republic, Thailand and other countries.

This report is based on his first visit to Bangladesh.

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Time given to me by members of the IADS team was much appreciated. Special thanks is given to Dr. Murray Dawson and Hugo Manzano who spent extra time consulting with me.

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At the same time, I wish to express my gratitude to a host of other scientists at many other government institutes who met and discussed their programs with me. Dr. S. Islam at BARI was most helpful in taking me to several programs and institutes, and assisting with my seminar arrangements.

SUMMARY

A two week consulting trip was made to Bangladesh to evaluate, recommend, and assist in planning the soil fertility research program.

Visits were made to many national institutes including BARC, BJRI, BARI, BRRI, CERDI, Jessore Regional Research Station, BAU and INA. Scientists were contacted and interviewed relative to their programs and soil fertility research. At most institutes laboratory facilities were visited.

Bangladesh is favoured with many well trained and intelligent soil scientists. Laboratory facilities are irregular from institute to institute; but in general are close to adequate in most cases. There appears to be a lack of a coherent national soil fertility program philosophy.

A recommendation was made to develop a Bangladesh soil fertility evaluation and improvement project that includes sampling, laboratory, interpretation, recommendation, research; and out-reach components. Recommendations and examples were given for each component.

An activity plan was developed.

REPORT TO BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) on Soil Fertility

by

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1.0 INTRODUCTION

It would be presumptuous of a person to consider that he had achieved an in-depth working knowledge of the problems, attemped solutions, available equipment, and personnel in the area of soil science in Bangladesh in the short period of two weeks.

The following report then, can only reflect the concepts obtained during this period. Undoubtedly, there will be some errors resulting from misunderstandings or incorrect verbal invormation. It is hoped that these are minimal.

It is the desire of the author that the reader overlock these minor errors when reviewing the overall concepts presented.

The importance of the role of soil fertility to Bangladesh agriculture has been expressed in many reports reviewed. It is one component of a national strategy that is needed to increase production on existing agricultural land.

The philosopies and opinions presented in this report are to be taken in the context of an integrated agricultural development system and not as an isolated soil fertility research program. They follow the same opinion as that

expressed on page 112 of the Report of the Review Team: Bangladesh Agricultural Research System presented below:

"It would appear that tillage, cropping systems, soil fertility and fertilizer use, and water management on different soil of the country should receive priority attention, in order to serve the farmer better. All of these needs to be tied to regional stations and linked to the farming systems research programs. Emphasis should be placed on use of multidisciplinary teams including soil scientists, agronomists, and economists, in order to ensure best use of soils information at farm level. In these studies explicit emphasis should be given to problems faced by different groups of farmers. Often larger farmers have the best land, which is also less likely to be flooded or exposed to other risks."

Bangladesh has four very positive aspects to its soil fertility program: a) an urgent need for practical information, b) a cadre of well trained soil scientists, c) relatively well equipped facilities, and d) a philosophy of cooperation and coordination in their research efforts.

This report reflects the consultants opinions with regards to the Terms of Reference (2) given below:

2.0 TERMS OF REFERENCE

The following are the terms of reference for Dr. Sam Portch, consultant in soil fertility to BARC from IADS.

2.1 Scrutinize the BARC Coordinated Soil Test Crop Response Correlation Project in terms of:

a) Approach and methodology

b) Objectives and achievements

c) Resource capabilities

2.2 Recommend alternate project strategies to accelerate achievement of generating valid and reliable fertilizer recommendations for Major System on Bangladesh Benchmark Soils.

2.3 Provide a Work Plan which would act as a guide to the BARC Coordinated Soils Technical Committee in implementing and monitoring recommendations as in (2) above. Include needed resource and manpower development needs.

3.0 OBSERVATIONS ON THE COORDINATED SOIL TEST CROP RESPONSE CORRELATION PROJECT (CST)

3.1 Introduction:

To scrutinize the CST strong reliance was made on information reported in the Bangladesh Agricultural Research Institute (BARI), Annual Report 1980-81 by the soil Science Division, and Bangladesh Agricultural Research Council (BARC) Soils and Irrigation Publication No.9. First Annual Report of CST as well as conversation with soil scientists in various institutes.

Only observations are made in this section. Recommendations are presented in section 4.

3.2 Approach and Methodology:

At the marco level both the approach and methodology appear to be good. From reading reports one observes that a coordinated and unified methodology is being used. This is beneficial and will result in a more efficient generation of useful information.

However, there are some problems or inconsistencies that appear when one reaches the micro-level of observation. Examples may explain these.

a) Chemical extractants used to determine available elements such as P, K, S, etc. are not always the same from institute to institute. When asked the reason for this, one soil scientist stated that each laboratory used whatever method was thought best or had been using for some time (traditional).

b) The traditional experimental design used to do the correlation studies (often referred to as a missing element trial) has certain inherent deficiencies. This results in the lack of correlation between soil analyses and field responses to the element. A missing element study should test only the element of interest within one treatment. This has not been done. Therefore, the utilization of much of the data for correlation studies is limited. In depth interpretation of each trial is necessary. This situation is being improved for the 1982-83 trials, at least at BARI.

c) Field observations of one trial left doubts as to its usefulness for soil test correlation. Factor other than soil fertility were obviously markedly limiting yields of all treatments (in this case it was disease problems).

d) No coordinated effort has been made to standardize reporting or units.

3.3 Objectives and Achievements:

No written overall objectives for the STC project were found in the documents reviewed. This may be the reason for taking measurement and collecting data that may be somewhat irrelevant to the experiment.

However, objectives are eluded to in the introduction of the Soils and Irrigation Publication No.9 of BARC. The following statements are made:

a) "It is highly important to evaluate fertility status of various soils and find out most economic and sound fertilizer management practises to attain desirable production within the limited means of the country."

b) Agriculturally advanced countries like USA, UK, Germany, Holland, New Zealand, Australia, Phillipines, and Japan have been using the concept of soil test crop response correlation for making fertilizer recommendations for agricultural crops."

If we assume that the statements selected are close to the general objectives of the STC project; then, they are basically sound and correctly concieved for a soil fertility research program.

It is extremely difficult for a short term consultant to determine the extent of the achievements of a program or project without knowing its history.

From comments and documents reviewed it appeared that soil science at one time was a very high priority research field. But, due to lack of coordination, and a proliferation of non-farmer oriented research, soil science did not achieve the expected impact. Fertilizer recommendations were not scientifically based, and the overall soils program was not service oriented. Because of this situation STC was formed and its first coordinated research done in 1980-81.

Taking this approximate date as a baseline from which to evaluate achievements one can state that they have been good and positive. First, the recognition of the need for the formation of the STC project can be considered a major achievement. Secondly, STC has initiated trials, and is (at least at BARI 1982-83) improving on the experimental design and will get better correlation information for making recommendations. Thirdly, BARC, probably through influences from STC team members, realized the need and requested technical assistance in the area of soil fertility.

Thus, very positive achievements have been made by STC. Still much more needs to be done towards focusing research

priorities on developing practical quick impact recommendations; as well as obtaining basic information and developing methodology for refining them.

3.4 Resource Capabilities:

It was a pleasant surprise to read that in 1981 there were 15 Ph.D, and 79 MS level Bangladesh soil scientists. According to Dr. M.A. Hannan of BARC, these are conservative figures.

It was a further pleasure to meet some of these people and discuss technical aspects with them. Their high quality of training was apparent. A general awareness of the need to develop a more viable national soil fertility program in Bangladesh, was prevalent.

The human resource base in soil science research in Bangladesh is good. Training needs around are minimal at the professional researcher level.

No assessment was made of the human resource base of extension or on-farm researchers. It was stated to me by more than one soil scientist to be weak. Of course, most of the training of this level of technician could be done in-country.

At the same time, it was surprising to see the number of available laboratory facilities that range from adequate to unsatisfactory. If a consolidation of some of these could be done, very little additional equipment would be necessary to have a model laboratory.

There are; however, resource deficiences with regard to on-farm research facilities. Most institutes are restrited to regional station trials because of the lack of vehicles.

No assessment was made of field research equipment. In most cases, when working with small farmers, equipment needs are minimal and can be manufactured locally.

4.0 RECOMMENDED ALTERNATE PROJECT STRATEGIES

4.1 Introduction:

Much has been achieved by Bangladesh soil scientists. Any suggestions made herein, assume that the recommendation would integrate with on-going work, would capitalize on the well trained human resource base, and would require a minimal input of new equipment.

The objective of the recommendations made is to achieve a rapid impact with Bangladesh farmers, while maintaining a systematic research approach for long term development.

It should be clearly understood by policy makers, donor agencies, and the general public that agricultural science, or in a broader sense, agriculture, is a dynamic system. Changes are made at the field level because of external policy decisions, climate alternatives for the farmer, his management and a multitude of other factors. It is, therefore, unwise to think of agricultural research as static. No one recommendation will be forever. There is a continual need to refine recommendations to meet changes at the field level. Thus, an agricultural research program must be developed not only to attach immediate problems, but also be structured so that it can grow, develop, and flow to new research areas and problems as they develop, or as priorities change. The same is true for a soil science research program.

It should also be clearly understood that a soil science research program should not be isolated. The fundamental yield equation that states that yield is a function of (Climate, Crop, Management and Soil) helps place the role of soil fertility into the agricultural picture.

It should be clear from this equation that the soil scientist cannot separate himself even in his biological evaluation of yield, from such factors as climate, types and varieties of crops, soil physical characteristics, and the management levels and capabilities of the farmer who will use his researched recommendations. Thus, a soil fertility research program must look outward and be multidisciplinary in its nature. This point is made once here but applies to all discussion and strategies outlined below.

The ultimate goal of a successful soil fertility evaluation and improvement program is efficient economical crop production including increased yields and quality, through the proper use of fertilizer, lime and other soil amendments.

4.2 A Soil Fertility Evaluation and Improvement Program:

There are two important words in the above title. They are evaluation and improvement. A soil fertility evaluation and improvement program involves much more than establishing and operating a laboratory. Actually, there are six major phases or components. These were clearly described in many of the publications of the International Soil Fertility Evaluation and Improvement (ISFEI) project of North Carolina State University, a USAID funded program. After termination of funding of the ISFEI project these principles were carried on by Agro Services International (ASI) a private corporation at Box 667, Orange City; Florida, 32763, USA. Some literature may be available from that source. The six phases, sampling, laboratory, interpretation, recommendation, research, and out-reach will be discussed below and strategies recommended for each component. They must operate simultaneously within the program.

4.2.1 Obtaining Representative Samples of both Soil and Plant Material:

The sample to be analyzed in the laboratory must represent the condition about which information is desires. This requires both research and training in order to reduce sampling errors.

Standard sampling procedures have been developed and suggested for other countries. Some of those can probably be immediately adopted in Bangladesh. For example, it would be expected that a soil sample made up of 30 sub-samples taken to plow depth, would be representative of the field from which it was taken.

On the other hand, time for best soil and plant tissue sampling may have to be researched. Sometimes, as the case may be in Bangladesh, sampling dates are dictated by climate.

Sample handling and storage systems will need to be developed. It is strongly recommended that permanent identification and storage facilities for all samples taken from soil fertility research plots be arranged. Samples will then be available for analysis at later dates by newly developed techniques. The field data for correlation will be on file.

4.2.2 Laboratory:

A laboratory should be established that will service both researchers and farmers. This laboratory should be a model. By being active with both types of analyses, both equipment and technicians will be maintained at higher performance.

Laboratory analyses of both soil and plant materials must be both rapid and accurate. Farmers and researchers do not

want incorrect information. They do not want the information after the crop is planted. The laboratory must be of high capacity to meet seasonal needs.

Equipment must be sturdy, dependable, easily maintained and adequate for the desired analyses. Both the farmer and researcher must be provided with all of the soil test information they need; and not a partial analysis. For example, an analysis and recommendation for only N. P, and K are of dubious value if the farmer has a major problem with S or Zn.

The farmer or researcher should also receive the same information and recommendation if he sends the same sample to two or more laboratories. Thus there needs to be a unified methodology based on soil test correlation studies. The methodology should be evaluated and updated annually, but should be agreed upon and used by the major laboratories.

Once a standard methodology is accepted a quality control system should be developed between laboratories. The following in laboratory and betwen laboratory system is suggested.

Each laboratory should have control samples of both soil and plant materials.

a) One control sample should be analyzed with each 10 unknown or farmers samples. The laboratory technician should know the results to expect from this control sample so that analytical or mechanical errors can be spotted immediately.

b) The head of the laboratory should submit control samples whoe results are known only to him. The frequency depends on total samples analyzed. This will guarantee that his laboratory technicians are controlling quality correctly.

c) A certain number of samples should be interchanged between different laboratories. Number and frequency would have to be established. One control laboratory; in the case of Bangladesh probably at BARI, could coordinate this activity.

d) The control laboratory would infrequently (once every 3 months) send 4-5 samples to a laboratory in the exterior so that results can be compared. This will give the central laboratory credibility not only with other laboratories, but also with researchers in the private sector.

There is a statement on page 112 of the Report of the Review Team: Bangladesh Agricultural Research System that more or less sums up the soils laboratory situation in Bangladesh. "The country has a bewildering number of institutions that conduct soils research". It seems that each one of these "bewildering number" also has a soil and plant laboratory. Furthermore, plans are underway to equip more of these throughout the country at regional stations. The wisdom of this should be studied.

There are advantages and disadvantages to centralized and decentralized systems of laboratories. These may be expressed as follows:

a) Advantages of Regional Soil and Plant Analysis Laboratory:

a.1 Results and recommendations returned to the farmer 3-4 days earlier.

a.2 Sense of closer personal contact by the farmer with the laboratory.

b) Disadvantages of Regional Soil and Plant Analysis Laboratory:

b.1 It is difficult to obtain and maintain a large number of highly qualified technicians to do the analyses in regional stations.

b.2 Often, general public services such as water and lights are not dependable. Equipment may be damaged by failures.

b.3 Services failures also may result in delays in getting the results back to farmers. Analyses are generally continuous once the process is initiated. Failures can result in having to initiate the process the following day.

b.4 An immense problem of quality control results because of human and physical errors at the different laboratories.

b.5 The farmer and researcher will probably not get as complete an analysis as needed. It will be too costly to equip the regional laboratories well. For example, at Jessore, we were told that the on-farm trials division analyzes soil for farmers. The farmer receives information on N, pH and texture; nothing on P, K, S, or Zn.

b.6 If sufficient funds were found to adequately equip all of the regional laboratories the per sample cost would be extremely high because of high fixed costs. For example, the per sample cost may be $10.00 for a laboratory that runs 500 samples a year as compared to $3.00 when 5000 samples are analyzed.

b.7 Service to equipment by specialized technicians is irregular and expensive.

c. Advantages of a Central Soil and Plant Abalysis Laboratory:

c.1 It is generally easier to maintain high quality control because of 1) availability of good technicians, 2) easier access to repair technicians, 3) more samples analyzed daily; therefore, more specialized personnel and more control samples analyzed.

c.2 Lower unit cost per sample

c.3 Better chance of establishing a self-sufficient unit with respect to water, light, and air-conditioning in instrument rooms.

c.4 Better chance of establishing a system of complete analyses.

c.5 A central system can use data for development of a soil fertility map, organize fertilizer distribution, and promote the service both to farmers and politicians.

d) Disadvantages of a Central Soil and Plant Analysis Laboratory:

d.1 The service could be slightly slower than the regional laboratory, but this should never exceed 4 days.

d.2 A large number of farmers or researchers would not have direct contact with the laboratory technician. His contact would be through the extension agent.

From the above, it can be concluded that for both research and farmer service, a well equipped, well organized central soil and plant analysis laboratory would be the most favorable system. This does not preclude the necessity of a small oven or balance for a regional station for sample drying or immediate moisture analyses.

A central system, would require considerable changes in the present struture and methods of operation. According to technicians at Jessore, results from samples sent to both the BARI soil science and on farm research division laboratories, were never returned to the local level.

At present, nearly all samples analyzed are for researchers. Very little emphasis has been put on farmers samples, or on a systematic scheme within zone with the objective of developing a farmer recommendation. During discussions at various laboratories

estimates of 200 samples per year, 400 samples per month, and 2000 samples per year were given. This is very low volume; therefore, exceedingly expensive and inefficient.

In other developing countries, using the ASI model laboratory and techniques, 100 samples can be analyzed daily with a maximum staff of 4-6 people. Samples receive determinations of pH, N, P, K, Ca, Mg, Zn, Mn, Cu, and Zn and S on demand in this system. Laboratories offering this service have been functioning continuous for as many as ten years. Time lapse from the moment the sample is received until the result is dispatched never exceeds 15 days, and is often 10. Major delays are in sample drying and report typing.

4.2.3 Interpretation of the Analytical Results:

This area of a soil fertility evaluation and improvement project requires both scientific knowledge and skill. What do the numbers means. How do you interpret the results in terms of plant requirements, fertilizer needs, timing and methods of application within various cropping systems.

Initially, this phase requires research to determine critical levels for laboratory results and knowledge of other factors that may influence the interpretation of the results of either soil or plant analysis.

4.2.4 The Recommendation:

From the analyses and interpretation phases, a recommendation must be developed for use of fertilizers, lime and other soil amendments. This must include a recommendation on amounts, method, and time of application as well as sources of materials. This has to be related not only to the soil analysis but also to crop varieties climatic conditions, pest management, and other cultural practices, as well as the farmers capacity to use the recommendation.

An initial guide sheet for a crop may resemble the following.

Crop: Wheat

Soil Analysis	Kg/ha N	Pz O5	Kz O
Low	120	160	60
Med	100	60	20
High	80	0-20	0

With this type of guide sheet, and the actual soil analysis data, a trained and competent regional soil specialist can make a recommendation to the farmer. The specialist will use his local research experience, knowledge of the farmers management level, and available materials, on which to base the recommendation.

This technician will have to be trained not only in the science, but also in the art of making a recommendation. It would be ideal for this person to be a regional soils research person, or have access to such a technician.

Only through proper use of recommendations will the goal of the soil fertility evaluation and improvement program be reached.

4.2.5 Soil Fertility Research:

4.2.5.1. Introduction:

Soil fertility research is done to provide reliable answers to certain questions such as how much fertilizer needs to be applied under a given soil fertility condition, what type of material should be used, at what time during the crop or cropping system, and what method of application is most effective. Generally, several different laboratory, greenhouse, and field trials are needed to obtain the information. For each type or series of trials it is important that a project be developed with clear objectives, plot design, data to be taken, and responsibilities assigned.

At the same time, it should be remembered that each project proposal should be written with flexibility so that minor modifications in procedures (changes in elements or levels studied), can be made without preparing a new formal proposal. The soil scientist should spend as little time preparing proposals

as possible. Most of his time should be spent on his research and transferring his findings to out-reach personnel.

Soil fertility research in Bangladesh needs to be focused on both short and long term needs.

Three integrated areas, a) laboratory, b) greenhouse and c) field research must be developed simultaneously.

4.2.5.2 Laboratory Research:

There are numerous types of laboratory research that can be performed. That suggested for Bangladesh; however, is focused on obtaining the maximum reliable information in the shortest time. Two major types should be done. These are a) research to determine best analytical procedures for soil samples for all elements, but with priority emphasis on elements demonstrated to be of major importance (N, P, K, S and Zn). Plant sample methodology of total element should be used. b) The second type of laboratory research involves the characterization of the fertilizer - soil interaction for major benchmark soils. This is done by using the technique developed by Dr. Hunter of ASI, called "sorption studies".

This methodology provides information, in a matter of two weeks, relative to the fate of added fertilizer to the soil. Certain soil characteristics, not easily determined, cause fertilizer materials to be "sorbed" or fixed, making them unavailable to plants. Often, traditional field trials fail to detect this phenomena.

4.2.5.3. Greenhouse Research:

The major emphasis on greenhouse/(shadehouse) research should be to achieve three objectives. First, to determine in the shortest period possible, major nutrient problems with identified soil

map units (20). This can be accomplished by a series of low cost greenhouse trials using the missing element technique, modified by Dr. Hunter of ASI.

Secondly, data from these studies can be used as a first approximation for correlating analytical procedures with crop responses so that the best analytical method can be selected for each element. This is simply done using the plastic overlay (or computer analysis) method developed by Cate and Nelson (ISFEI Technical Bulletin 1).

Thirdly, data from these greenhouse trials will serve as a basis for designing formal soil fertility field trials. For example, it is of limited value to study N, P, and K rates if another element such as S, Zn or Mn, limits responses. Greenhouse trials provide data on what elements need to be studied or base applied so as not to limit responses of elements under study.

With a concentrated effort, all of this information discussed in this section can be obtained in one year; once the system is working.

4.2.5.4. Field Research:

There are at least four major areas of field research that need to be simultaneously initiated. These are a) a diagnosis of the systems used by the farmer in the area of study. This includes cropping systems as well as socio-economic levelsand possibilities; b) short term on-farm quick impact research based on first approximations and present data; c) more formal studies designed to generate reliable data for chemical analysis and field response correlation; and d) studies to determine optimum biological and economical responses to fertilizer materials applied to different crops in a cropping system of several years.

After review of the listed documents (Appendix II) it become apparent that some minor changes need to be made in the design of soil fertility field trials and data interpretation.

Original trials having treatments: control, N_1, N_2, N_2 P, N_2 PK, N_2 PK S, N_2 PK S Zn and N_3 PK S Zn, have several weaknesses. A major prdlem is that N levels, or for that matter other elements, cannot be adequately evaluated if another element is limiting response. For example N levels cannot be studied if P, K, S etc. are limited. The advantage of the original trial design, was the small number of treatments (8).

A modification of this design that involves a large number of treatments (20-24) was presented by BARI soil scientist. This design has the advantage that it covers the problem illustrated above. However, it is extremly large for management in the field. A simpler compromise design is presented below.

An example is given using treatments for a cotton trial presented on page 7 of the BARI Technical Programme 1982-83 for soil science. Here there are 5 levels of N, 1 basal treatment of P (P is not evaluted in the trial), 4 levels of K and 3 levels of S to be studied. The incomplete factorial design has 24 treatments.

Without sacrificing much information the experiment can be reduced to a more manageable 12 treatments (Table 1). This design has the added advantage of making a with or without evalution of the need for P.

Table 1. Possible Treatments for A Simplified Cotton Soil Fertility Trial.

Treatment No.	N	P (Kg/ha)	K	S
1	0	50	90	40
2	60	50	90	40
3	90	50	90	40
4	120	50	90	40
5	150	50	90	40
6	120	0	90	40
7	120	50	0	40
8	120	50	60	40
9	120	50	120	40
10	120	50	90	0
11	120	50	90	20
12	0	0	0	0

A further reduction in treatments is possible by reducing the number of doses of N to four but spanning the same levels. Instead of 0, 60, 90, 120, and 150 Kg/ha; it is possible to use 0, 50, 100, and 150 to develop a curve from which optimum biological and economical data can be obtained.

Field research data interpretation techniques need to be modified. When factors (disease, climate, physical damage) other than those under study (elements) limit yield; data should be eliminated from correlation studies. This can readily be done by setting acceptable limits for crop yields in the trials. For example, if in one trial with wheat, yields, even for the expected best treatment, never are more than 1.5 t/ha while all other trials reach yields of 3.5-4.5 t/ha, one would suspect a limiting factor in the first trial. Including this data in a correlation study could adversely effect the results and interpretation.

It would also be beneficial for Bangladesh soil scientists to change their rigid use of statistical analysis. Holding statistical confidence limits to the 5% level and rejecting information outside of this as non-significant, is an injustice, particularly for regional and on-farm trials.

These field trials should be statistically analyzed at confidence limits of 25%, 10%, 5% and 1%, if applicable. The 25% limit state that 75% of the time a certain response or lack of it, can be expected. While this lower level of confidence may not be enough for making a recommendation to a farmer, it should not be ignored by the researcher. He should at least observe the trend it indicates and decide whether a more precise study is necessary to improve confidence before making a recommendation.

At the 10% level, the soil scientist should be willing to make a recommendation to the farmer. In effect he is stating that 90% of the time the farmer follows the recommendation he will achieve the response indicated. Those are pretty good odds.

Higher confidence limits are always better. They give the researcher more assurance in his recommendation. They should be sought through better management of experiments.

4.2.6 Out-reach.

The ultimate goal of a soil fertility evaluation and improvement program is economic crop production. This is achieved by getting the integrated practices described above, put into practise on farms and in fields. It is an out-reach program. It requires training of extension personal and farmers, demonstrations of improved practises, and often changing of political policies so that advantage can be taken of new technology.

Having a viable soil fertility evaluation and improvement program is a major advantage for any agricultural research institute. Because, the soil or plant sample sent to the laboratory for analysis can often be used as a link between the research institute and the extension worker and farmer. A program can be developed to supply these people with other pertinent information along with the fertilizer recommendation. For example, information such as previous crop, previous fertilization, size of field, crop to be grown, sequence in system etc., accompany a soil or plant sample when it is submitted for analyses. This information is needed for a sound fertilizer recommendation. This same information; however, could be used to provide a more complete recommendation that could include recommended varieties, and other cultural practices. Thus, a soil or plant sample can act as a link along which information that might otherwise remain in files in a research institute; can flow to the extension worker and farmer.

4.3 GENERAL RECOMMENDATIONS

The development of a soil fertility evaluation and improvement program as described above is essential to the progress of agricultural development of Bangladesh. Technical assistance to accelerate this program is necessary.

BARC should try and obtain all of the literature developed by the International Soil Fertility Evaluation and Improvement project headed by Dr. J.W. Fitts at North Carolina State University 1965-75. This may be possible through NCSU or by contacting Dr. Fitts at the ASI address given earlier. Seven technical bulletins were developed.

The technical assistance that can be provided by IADS should provide special assistance to the BARC and other interested institutes to do the following:

a) Orient the program more towards the farmer from both the research and service points of view. At present, few trials are being done on farms. Also few farmers soil and plant samples are being analyzed.

b) Organize both a precise and rapid laboratory service. A laboratory cannot be shut down because of lack of reagents, or mechanical breakdowns. Reagent management can usually be done by good planning once cash flow and reliability is known. In some countries delays due to mechanical breakdowns are overcome by duplicating electronic equipment. In Bangladesh it probably can be done by developing a cooperative spirit among the several soils laboratories.

c) Organize the purchase of certain laboratory equipment. That recommended by ASI for multi-analysis would be advisable. Furthermore, the lamps for the atomic absorption unit at BARI purchased with USAID funds need to be changed. Only 2 of the 7 lamps purchased are used for soil or plant analyses.

d) Assist the BARC in setting soil fertility research priorities and developing projects for these.

e) Integrate soil fertility research into the cropping systems program.

f) Assist local soil scientists to obtain a vehicle so that both personnel and materials can be transported to on-farm trials, field days, and training sessions.

It is also recommended that two types of surveys be made in order to establish a general knowledge of soils problems in Bangladesh. One is with soils - this is described below in the work plan. The other is with plant material - possibly following the suggestions of Dr. H. Sakai.

Special emphasis is given here to the importance of the cropping systems trials being conducted in the country. The importance of these trials and the role of fertilizers in them, cannot be overemphasized. However, cropping system trial treatments must be simple; but based on sound research if they are to be effective.

It is also recommended that cropping systems trials be carried on over a period of years at certain locations. Quick judgement on the acceptance or rejection of a practise could be misleading. For example, in one year the acceptance of a new crop may be negative because of biological (heavy bird attacks because crop is unique), or climatical (abnormal rain) constraints. Often, these limitations can be identified and modifications made to overcome the negative aspects.

When fertilizer use is considered in cropping system it should be done over several years at the same site. In some cases with the less mobile elements such as P, and K, their application may be considered more a capital type investment whose costs should be distributed over several years, rather than one crop. Experiments will have to be designed and strategically located (possibly on rented land were strict control can be maintained) to study this.

5.0 WORK PLAN

5.1 Introduction:

The development of a detailed work plan for a soil fertility evaluation and improvement program for a country requires detailed knowledge of facilities, personnel, transportation constraints, cropping seasons and systems, and other factors. This is impossible to obtain on the first short visit to a country. Therefore, the plan presented is general in nature.

The following plan of action assumes that the Bangladesh soil fertility evaluation and improvement (BSFEI) program will have one resident expatriate soil scientist, access to short term technical assistance, financing for internal and external training, and a reliable and adequate cash flow.

All activities of the soil specialist and other short term technical assistance personnel will be conducted with Bangladesh counterparts. Emphasis is on development of a national capability.

5.2. Plan of Action:

Most of the activities described below, will take place simultaneously.

Activity	Expected Result
1. IADS soil specialist arrives. Travels extensively in Bangladesh to interview researchers and farmers and observe soils and facilities.	Familiarize soil specialist with Bangladesh.
2. Meeting with soil scientists to discuss philosopies, objectives, methodology and evaluation procedures of the BSFEI program	Unify methodology and philosopies for an action program.
3. Obtain 300 kg of representative soil samples from the 20 major soil units being careful to assure that they are representative. These should be throughly mixed and sub-samples be sent to various cooperating laboratories. BARI should coordinate. Plant samples also obtained.	Samples used to characterized soils and to start quality control and methodology research.
4. One Kg of each sample from 3 above should be sent to ASI in Florida for complete analysis and "sorption" studies.	Baseline soil characterization. Major problems initially identified. Initial control samples.
5. BARC in cooperation with IADS soil specialist selects 3-6 soil scientists for 2-3 month training in US. Two months at ASI to : a) analyse Bangladesh soils and familiarize with methodology, b) do "sorption" studies c) treatment selection of modified missing element study for greenhouse trials,	A core of farmer service oriented Bangladesh soil scientists formed. A cooperative spirit between these techicians from different institutes. A systematic methodology learned that can be repeated or transferred in Bangladesh. Contacts for continued cooperation with US or other soil scientists.

d) establish, maintain and harvest some greenhouse trails,

e) train in management of service oriented soil and plant laboratory,

f) learn maintenance, and troubleshooting for laboratory equipment, g) visit specific field research in US or other countries.

6. IADS specialist will inventory laboratory equipment needs after attempting to put existing equipment into operation. Cooperation between institute laboratories will be initiated. Bangladesh personnel in US (5 above) will also determine needs.	Existing equipment functioning where possible. Equipment for model science laboratory ordered.
7. Short and long term experiments designed within the BSFSI program in cooperation with other IADS and Bangladesh researchers.	Integrated research planned
8. Laboratory, greenhouse and field research trials will be initiated using the 20 soil units as starting point.	Baseline soil characterization compared (in part) with ASI. First approximation of best extractant and expected responses in field.
9. Evaluation and Publication of data obtained in 8 above for laboratory and grenhouse	General understanding of major problems.
10. Field data evaluated and data published as it becomes available	General information on fertilizer use transferred.
11. Preliminary fertilizer recommendations developed for major crops. Meetings held with crop scientists, economists, extention workers, farmers and others to obtain opinions of recommendations. Final draft of recommendation guide sheets. Review of this done every 18 months.	Understanding of farmer and other constraints to ideal recommendation. These incorporated into first guide sheets.

12. Once 11 above completed, a series of technicians training sessions held to train out-reach personnel in use of guide sheets based on soil analyses	First farmer recommendations based on correlation studies. Increased fertilizer use efficiency. Improved yields and profit.
13. Laboratory technician training course on best methodology obtained from 9 above.	Unified methodology within Bangladesh.
14. Regional training courses (3) to train soil scientists in BSFEI concepts and methodlogy	National awareness of BSFEI concepts. Technology transfer
15. Interdisciplinary evaluation of BSFEI program coordinated through BARC. Progresses and problems as well as future planning discussed.	Imprvement in technological development. Improvement in BSFEI program. Awareness of BSFEI progress and Problems by administrators.

Table 2. APPROXIMATE TIME FRAME FOR ACTIVITIES FOR FIRST TWO YEARS

Activity (See, plan of action)	First Six Months	Second Six Months	Third Six Months	Fourth Six Months
1. Arrive and Travel				
2. Meetings				
3. Sampling				
4. Samples to ASI				
5. Technicians to ASI				
6. Laboratory Inventory				
7. Experiments designed				
8. Trials initiated				
9. Evaluation of Lab and Greenehouse Research				
10. Evaluation of Field Research				
11. First Recommendations				
12. Out-reach Training				
13. Laboratory Training				
14. Regional Training				
15. Evaluation and Modification				

APPENDIX 1

ACTIVITIES OF CONSULTANT IN SOIL FERTILITY TO BARC

Date	Activity	Persons Interviewed
July 9, 1982	Arrive Bangladesh	Dr. M. D. Dawson
July 10, 1982	Visit BARC Commence Document Review	Dr. M.A. Mannan Dr. K.M. Badruddoza Dr. A. H. Manzano Mr. R. Semmes
July 11, 1982	Sunday	
July 12, 1982	BARC Continue Interviews with Member Directors and IADS Staff. Continue Document Review	Dr. M. D. Dawson Mr. M.U. Ahmed Dr. B. Greene Dr. D. Davy Dr. E. Ahsan Dr. C. McClung Mr. L. Sikka
July 13, 1982	BARC Continue Document Review	Mrs. Joanne Hale Dr. M.A. Wahhab
	USAID	Dr. M.A. Ali
	BJRI	Dr. A.A. Azad Dr. A.L. Khandakar
July 14, 1982	BARI	Dr. M.S. Islam Mr. M. Hossain Mrs. S. Razia Mr. A.K.M. Rahman Mr. M.M. Alam Miss. K. Begum Dr. A.K.M. Amzad Hossain Dr. A.L. Khan Dr. M.H. Mondal Dr. K. Anam

Date	Activity	Persons Interviewed
July 15, 1982	BARI	Dr. M.S. Islam
	BRRI	Dr. K. Masumi
	CERDI	Dr. Shahiduzzaman
	BJRI	Dr. N.I. Bhuiyan
		Dr. S.M.H. Zaman
		Dr. M.A. Wahhab
		Dr. M.A. Ali
		Dr. A.A. Azad
		Dr. S.A. Ahmad
		Dr. A.L. Khandakar.
July 16, 1982	Jessore Regional Research Station	Mr. Paul Villegas and BARI Research Staff.
July 17, 1982	BARC preliminary Report Writing	
July 18, 1982	Preliminary Report Writing and preparation of Seminar	
July 19, 1982	BAU	Dr. Bhuiyan Dr. Hoque Dr. Eunus
	INA	Dr. Habibullah

Date	Activity	Persons Interviewed
July 20, 1982	BARC Presentation of Draft	Dr. M.A. Mannan Dr. M.D.Dawson
	BARI Presentation of Seminar	
July 21, 1982	BARC Final Report Prepared and presented to Executive Vice-Chairman	Dr. M.A. Mannan Dr. K. Badruddoza
July 22, 1982	Departure	

APPENDIX II

MAJOR DOCUMENTS REVIEWED

1. Programs in the Agricultural Research Project Phase-II by The Bangladesh Agricultural Research Council. 1981.

2. Management Monitoring and Evaluation of Agriculture Projects Supported with an Information system, by M.U. Ahmed and Dr. M.D. Dawson. Bangladesh Agricultural Research Council. 1982.

3. Programs in the Agricultural Research Project USAID Phase-II 1981-86. Bangladesh Agricultural Research Council. 1981.

4. Inventory on Manpower and Physical Facilities Available for Irrigation and Water Management Research in Bangladesh by Soils and Irrigation Division, Bangladesh Agricultural Research Council. 1981.

5. Soil Conservation Needs in Bangladesh by D. Layzell. FAO/UNDP Land Use Policy Project. 1982.

6. Characterization of Soils for Non-Irrigated Rice Cultivation in Bangladesh. by H. Brammer FAO Agricultural Development Adviser. 1982.

7. Study of Village Lands Made Derelict by Non-Agricultural Activities. by Tjapko Jager FAO/UNDP Agricultural Development Adviser Project. 1982.

8. Potassium in Bangladesh Soils and Crop Response. by Dr. Z. Karim. Bangladesh Agricultural Research Council. Soils and Irrigation Publication No. 6. 1980.

9. Soil Test Crop Response Correlation Studies of Wheat, Potato, Cotton, Tobacco, Gram and Lentil. by Division of Soil Science. Bangladesh Agricultural Research Institute. 1982.

10. Fertilizer Guide for Major Crops of Bangladesh. by The Sub-Committee. Soils and Irrigation Publication No.4. Ed. A.N.M. Mahbubul Alam. Bangladesh Agricultural Research Council. 1979.

11. Report of the Review Team: Bangladesh Agricultural Research System. 1980.

12. First Annual Report: Coordinated Soil Test Crop Response Correlation Studies. by A. Committee. Soils and Irrigation Publication No.9 Bangladesh Agricultural Research Council. 1982.

13. Technical Programme (1982-83): Soil Test Crop Response Correlation Studies for Wheat, Potato, Cotton, Tobacco and Pulses. by Agricultural Chemistry Section. Division of Soil Science. Bangladesh Agricultural Research Institute. 1982.

14. A BARC Paper and Proposal: The Potassium Fertilizer and Research Needs for Bangladesh. Auther unknown.

15. Training Programme on Irrigation and Fertilizer Management at Farm Level Sponsored by BARC.

16. Regional Agricultural Research Station. Jessore.

17. Grain Analysis for Estimating Nutrient Deficiency of Soil. by Dr. H. Sakai. 1982.

18. Various correspondence and miscellaneous reports.