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**STATISTICAL SUPPORT
FOR
FARMING SYSTEM RESEARCH (FSR)**

A Consultancy Report

by

Roger G. Petersen

September 1991

PARC • USAID • MART • WINROCK

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A

The MART (Management of Agricultural Research and Technology) Project is funded by the United States Agency for International Development (USAID). The MART Project's chief link to the Government of Pakistan is through the Pakistan Agricultural Research Council (PARC). A MART Project Coordination Committee composed of federal, provincial, and university representatives coordinates and guides project activities. Its purpose is to assist the Pakistani agricultural research system to strengthen its research management capabilities, and to improve communications, training, farming systems research, arid zone research, and research in the rural social sciences. Winrock International, through a contract with USAID, has responsibilities to assist with the first four of these tasks. Two international agricultural research centers, the international maize and wheat improvement center (CIMMYT) and the International Center for Agricultural Research in Dry Areas (ICARDA), are responsible for the other two tasks.

The mission of Winrock International Institute for Agricultural Development is to help reduce poverty and hunger in the world through sustainable agricultural and rural development. Winrock International assists people of developing areas - in Asia, Africa and the Middle East, Latin America and the Caribbean, and the United States - to strengthen their agricultural institutions, develop their human resources, design sustainable agricultural systems and strategies, and improve policies for agricultural and rural development. As an autonomous, nonprofit organization, Winrock International provides services independently as well as in partnership with other public and private organizations. The institute is recognized as a private voluntary organization.

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Abstract

I. CONSULTATION WITH INDIVIDUAL SCIENTISTS

A. NARC

1. Statistics and Computer Unit
2. Crops Research Institute
3. Animal Sciences Institute
4. Water Resources Group

B. FAISALABAD

1. FSR Scientists

C. MANSEHRA, NWFP

1. FSR Scientists

D. QUETTA, BALUCHISTAN

1. Arid Zone Research Institute
2. Agricultural Research Institute, Sariab
3. ICARDA Scientists

II. FSR REPORT PRESENTATIONS

A. FAISALABAD

B. MANSEHRA

C. NARC

III. WORKSHOPS

A. Trial Design, Data Collection, and Economic Analysis - Faisalabad.

1. Leader of a one day session on Biometrical Issues.

B. Experimental Design and Statistical Analysis Workshop, NARC.

1. Conducted a two-day workshop on Basic Biometrical Issues and on-Farm Trials in Farming Systems Research. Participants included 4 from Faisalabad, 3 from Mansehra, 2 from Quetta, 2 from NARC, and 1 from Tandojam.

IV. MANUAL OF EXPERIMENTAL DESIGNS FOR ON-FARMS TRIALS IN FSR

- A. Prepared a manual for On-Farm Trials**
 - 1. Trials with Crops - Four Experimental Designs.
 - 2. Trials with Animals - One Experimental Design.
- B. Statistical Analysis and Interpretation of Each Design.**
- C. Numerical Illustrations.**

I. Introduction:

The principal goal of this consultancy was to work through the FSR coordinators to improve the validity and reliability of Farming Systems Research. This goal was to be accomplished in a number of ways including:

1. Development of efficient, statistically sound experimental designs for use in On-Farm Trials, not only for systems based on crops but also those in which animals are involved.
2. Development of seminars, short courses, and workshops on Experimental Design and Analysis for the training of a cadre of instructors to work with others on these topics throughout Pakistan.
3. Consultation with FSR scientists at NARC and in the provinces on Biometrical issues associated with Farming Systems Research.

The ultimate aim was to build a basis for an appreciation of, and a foundation for, statistically sound research in Farming Systems.

The approach used here was to consult with research scientists, particularly those doing FSR, both in the provinces and at the National Agricultural Research Centre. These consultations provided insights into the Biometrical problems associated with doing FSR in general, and On-Farm Trials in particular. In addition, meetings were attended, both at NARC and in the provinces, at which the results were presented and discussed. Further, I participated in a workshop on FSR Trial Design, Data Collection, and Economic Analysis. This workshop, attended by scientists from throughout the country, was held in Faisalabad in early August.

Information gained from these consultations and meetings, and in discussions with National and Regional FSR Coordinators and the Farming Systems Advisor for the MART/Winrock Project, led to the development of a two-day workshop on Experimental Designs for On-Farm Research. This workshop was held at NARC and was attended by FSR scientists from NARC and from the four provinces.

Finally, because Experimental Designs aimed specifically at On-Farm FSR trials have not previously been available a series of designs for On-Farm Trials with crops and a Design for On-Farm Trials with animals were developed. A manual which includes these designs and the procedure for analyzing the data from them has been written.

II. Consultations:

Consultations were arranged with scientists both at NARC and in the provincial agricultural research centres. These sessions included the Statistics and Computer Unit at NARC, the Crops Research Institute (CRI) and the Animal Sciences Institute (ASI) at NARC, the Agricultural Research Station, Dhodial, at Manshra, the Arid Zone Research Institute (AZRI) and the Agricultural Research Institute (ARI) Sariab, at Quetta. Consultations were also arranged with individual scientists at NARC and with the National Coordinators and the MART Advisor for FSR Research.

The discussions with the staff of the Statistics and Computer Unit, NARC, were particularly helpful. This unit is responsible for processing much of the research data generated at NARC. The unit also provides advice to the research scientists on the selection of Experimental Designs to be used in their research. The unit, therefore, is in a position to get a broad look at the kinds of research taking place at NARC. They are more interested, however, in the technical problems involved with statistical analysis than the problems associated with On-Farm Trials.

The scientists in the CRI and the ASI at NARC were also more concerned with design and analysis problems associated with On-Station component research than with On-Farm Trials. On the other hand, the National Coordinator for FSR is a member of the CRI staff. He provided some insight into the problems associated with the design and analysis of On-Farm Trials. Similarly, the poultry section of the ASI have been doing some On-Farm work, The poultry scientist posed some interesting questions on the conduct of these trials and on the interpretation of data from them, particularly economic interpretation, and on the necessary amount of replication.

Discussions with scientists at AZRI and the provincial stations at Manshra and in Quetta were helpful. People at these stations have actually been doing On-Farm Research. They provided insight into the problems of planning and field operation of such trials. They also raised some questions about the design of the trials and the selection of treatments for them.

A general conclusion reached from these discussions was that the scientists are having difficulty separating On-Station component Research from On-Farm FSR. The fundamental principle in FSR is to use On-Station Research in its usual form to examine possible practices to be recommended to the farmers. Once these components have been studied on the station they are formed into a single package of improved practices to be taken to the farmer's field. The On-Station study usually involves experiments including several components at several levels. The experimental design is usually fairly elaborate.

On-Farm FSR, on the other hand, should be fairly simple. An improved practice, containing components which have been tested On-Station and which are believed to be superior

to present practice, is compared with the practice now being used by the farmer. The experimental design should be fairly simple. It should be set up, basically, to compare two treatments, the improved practice and the farmer's practice.

Discussions with the scientists indicate that, in many instances, they look at On-Farm Trials as if they are doing On-Station Research on the farm. In some cases fairly complex experimental designs using multiple treatments have been used. This would seem to be counter productive since one of the purposes of On-Farm FSR is to demonstrate to the farmer and his neighbors the benefits of an improved practice. This type of demonstration is impossible with the usual On-Station Experimental Design since this type of design does not provide direct side-by-side comparison of the improved practice and the farmer's practice.

A second observation obtained from the discussions with the scientists has to do with replication of the On-Farm Trials. They realize that replication is necessary for assuring the statistical validity of the results. However, they are not really sure what constitutes true replication, nor are they informed about the number of replications necessary to provide the minimum level of acceptable precision.

These issues must be addressed before meaningful results can be obtained from On-Farm Trials. There are a couple of ways this can be done. Face-to-face instructions can be presented in the form of workshops, training sessions, etc. It also can be done by providing written material in which the design and analysis On-Farm Trials is presented. I used both approaches to provide information on statistically valid methodology for On-Farm Trials in FSR.

III. Workshops:

One day of the workshop in Faisalabad was devoted to a presentation of biometrical issues. Some of the basic principles of experimental design and research planning were presented and discussed. In addition, a simple experimental design for On-Farm trials involving animals, and the statistical analysis of data from this design, was presented and discussed. At the request of the workshop participants I made available copies of a write-up of this design.

On 20-21 Aug. I conducted a workshop on "Experimental Design and Statistical Analysis". The original intention of this workshop was to go over the highlights of a manual entitled "Experimental Designs in Agriculture" which I had written during a previous consultancy. This manual is published by PARC and is widely available to research workers throughout Pakistan. The purpose of the workshop was to begin to develop a cadre of trainers who could work with applied scientists throughout the country.

The workshop was attended by 12 participants including four from NWFP, two from Quetta and two from NARC. All of the participants were field scientists and many of them were actively involved in FSR.

The first day of the workshop was devoted to basic considerations in research planning, and an examination of simple experimental designs and their analysis. This was followed by discussions among the participants and by the presentation of specific statistical problems for me to consider and offer suggestions on.

The original intent for the second day was to consider some more complicated experimental designs as well as some procedures for detailed statistical analysis of research data. At the request of the participants, however, I decided to consider experimental designs specifically for use in On-Farm trials. Accordingly, the first part of the second session was devoted to consideration of designs for On-Farm trials involving crops. The second part was used to consider On-Farm trials involving animals.

The final agenda for this workshop is included as Annex D to this report.

IV. Manual of Experimental Designs for On-farm Trials:

Experimental designs for use in On-Farm trials must meet a number of criteria:

1. They must be easy to lay out and manage.
2. They must require no more than a few treatments.
3. They must provide for easy on-site comparison of a recommended practice with the farmer's practice.
4. They must permit a relatively simple statistical analysis of the resulting data.

It is possible to find such designs in the standard experimental design texts. However, it would be much more satisfactory to have a collection of experimental designs for use in On-Farm trials in one manual or other similar publication. Such a manual would be useful for FSR scientists doing On-Farm research for two reasons:

1. It would present a set of appropriate designs and their statistical analysis.
2. It would direct the scientists away from the types of designs used in on-station research and toward types of designs useful for On-Farm trials.

During this consultancy I prepared a manual of experimental designs for On-Farm trials. The manual contains two class of designs, one for trials involving crops and the other for trials with animals. Both classes of designs are intended for trials with basically two treatments: Farmer Practice (F) and Improved Practice (N).

The crop-based trial designs are, essentially, randomized block designs with farms as blocks. Four designs are described:

1. Basic two-treatment design
2. Design for improved practice with two components.
3. Design for improved practice with three components.
4. Basic design with supplementary treatments.

All of these designs involve two large plots, one for the farmer's practice and one for the improved practice. Some of the designs include small plots for component and supplementary treatments. A single replication of the treatments is used on each farm.

Yields are measured on each plot, reduced to a per unit area basis, and subjected to an analysis of variance. Further, for the trials involving two or three components, the effects of the individual components and their interactions are studied. The aim of the statistical analysis is to determine the significance of the increased yield from the improved practice compared to the farmer's practice.

The experimental design for on-farm trials involving animals requires the study of animal performance for two successive periods. A number of farms is chosen in the target area. On each farm the animals are divided into two groups. The groups are then treated with the farmer's practice, F, or the improved practice, N. One group receives the treatments in sequence F - N, while the other group receives the sequence N - F. The characteristic of this design is that each treatment is applied to a farmer's group of animals in each period. The aim is to eliminate group differences from the comparison of treatments.

Performance is measured on each group in each period, then expressed on a per-animal basis. The significance of any increased performance from the improved practice is then determined using a statistical analysis.

The manual includes a detailed description of each design as well as the statistical analysis appropriate for each. Also included are numerical examples which illustrate the analysis and interpretation of each design.

Although it is not included as an integral part of this report it is assumed that this manual will be an important supplement to it. The table of contents is included as Annex E to this report.

Terms of Reference

**Biometrician
Roger G. Petersen**

The consultant in statistics will assist the national FSR Coordinators to improve the validity reliability and management of on farm systems research:

1. In design and implementation of economically efficient and statistically sound experimental designs for on-farm studies.
2. In the analysis and interpretation of data from FSR area projects and in planning system interventions with acceptable experimental design for on-farm research that include livestock.
3. In initiating a seminar series on biometric issues, making use of the cadre of instructors in design to conduct courses in the provinces. The initial topic in these courses should be basic experimental design. As experience is gained, the instructors might want to develop short courses or workshops on more specialized topics.
4. In providing consultancy to FSR Scientists in the provinces on biometrical problems and developing a strong interface with provincial agricultural scientists.
5. In helping assign priorities to various researchable issues and assist to formulate a coordinated FSR research project methodology on experimental design and biometry.

To accomplish these tasks the consultant will travel to each of the provinces (if possible) to conduct short courses and to advise FSR researchers on experimental design and biometry. He will also assist the FSR Coordinating cells in the same subjects.

Itinerary

- Aug. 5 Travel from Karachi to Islamabad via PK-360 (2330-0100)
Aug. 6 Visit USAID, NARC
Aug. 7 NARC - Meet with Computer and Statistics Unit
Aug. 8 NARC - Computer and Statistics Unit. Meet Member Social Sciences, PARC.
Leave for Faisalabad via PK-657 (1930-2015)
Aug. 9 Prepare Presentation for workshop
Aug. 10 Participate in workshop, Agricultural University
Return to Islamabad via PK658 (2050-2200)
Aug.11-13 NARC- meet with CRI staff
Aug. 14 Staff house - work on experimental design manual
Aug. 15 NARC - meet with ASI staff
Aug. 17 Staff house - work on manual
Aug. 18 By road to Manshra - attended presentation of FSR
results, individual discussions. Return to Islamabad.
Aug. 19 NARC - presentation of FSR results by scientists
Aug.20-21 NARC - conducted workshop on experimental design and
statistical analysis
Aug. 22 PARC - meet with member, Social Sciences.
Finish design manual at Staff house.
Aug. 24 Travel to Quetta via PK381 to Lahore (1230-1300) then
via PK321 (1430-1550) to Quetta.
Aug. 25 AZRI-consult with scientists in AZRI and ICARDA
Aug. 26 ARI, Sariab - consult with Scientists
Aug. 27 Return to Islamabad via PK 324 (1135-1300)
work on consultant's report in Staff House.
Aug. 28 NARC - work on draft of manual and activity report
Aug. 29 NARC - final draft of manual - wrap meeting up
at USAID with Dr. Senykoff and Dr. Weller
Aug. 31 Staff house - work on consultant's report
Sep. 1 Staff house - work on consultant's report
Sep. 2 Depart for USA via PK311 (1230)

LIST OF INSTITUTIONS VISITED AND PEOPLE CONTACTED

PAKISTAN AGRICULTURAL RESEARCH COUNCIL

Dr. Agha S. Haider, Member, Social Sciences

MART/WINROCK PROJECT

Dr. Bill C. Wright, Chief of Party
Dr. Murray Dawson, Advisor, F.S.R.
Dr. Cordell Hatch, Advisor, Information Transfer
Dr. Marlin Van Der Veen, Consultant
Dr. Takumi Izuno, Research Advisor
Dr. James Barnett, Research Advisor
Dr. Daud A. Khan, Horticulturist

USAID - ISLAMABAD

Dr. John Swanson, Dept. Dir.
Dr. Ronald Senykoff, Agr. Dev. Officer
Dr. Dennis Weller, Agr. Dev. Officer

NATIONAL AGRICULTURAL RESEARCH CENTER

Dr. M. A. Sial, Acting Director General (Member, Animal Sciences, PARC)
Mr. Naseer A. Khan, Dir. Computer and Statistics Unit
Mr. Inayat Khan, Computer and Statistics Unit
Dr. Mansab Ali, National Coordinator, FSR
Mr. M. Azeem, Asst. Nat. Coordinator, FSR
Dr. N. I. Hashmi, Director, Crops Research Institute
Dr. S. Masood, Plant Breeder, CRI
Dr. M. Munir, Agronomist, CRI
Dr. B. Malik, Pulses, CRI
Dr. M. Anwar, Coordinator, ASI
Dr. M. Q. Chattha, Director, Crop Maximization Project
Dr. A. H. Cheema, Director, Animal Sciences Institute

NWFP AGRICULTURAL UNIVERSITY

Dr. G.M.Khattak, Vice Chancellor
Dr. C.L. Hausler, Livestock Advisor, Tipan Project
Dr. A. Q. Khan, Project Officer, Tipan Project

UNIVERSITY OF AGRICULTURE, FAISLABAD

Dr. S. H. Hanjra, FSR Coordinator

AGRICULTURAL RESEARCH INSTITUTE DHODIAL, MANSEHRA

Mr. G. Khan , Regional Director

ARID ZONE RESEARCH INSTITUTE, QUETTA

Dr. B. R. Khan, Director General
Dr. H. Raza, Deputy D.G.

AGRICULTURAL RESEARCH INSTITUTE, SARIAB, QUETTA

Dr. A. H. Bajoi, Director
Mr. S. M. Anees, Agronomist
Mr. Q. B. Ahmed, Agricultural Economics

ICARDA, QUETTA

Dr. Alistair Allen, Agronomist

**WORKSHOP ON EXPERIMENTAL DESIGN AND
STATISTICAL ANALYSIS**

Venue: Lecture Hall, Training Institute, NARC

Aug. 20

09:00-11:00 Opening remarks
Basic considerations on research planning
Discussion

11:00-11:30 Tea

11:30-13:30 Basics of experimental design
Completely randomized design
Randomized block design
Numerical examples
Discussion

Aug 21

09:00-11:00 Designs for On-farm trials with crops
Numerical examples
Discussion

11:00-11:30 Tea

11:30-13:30 Designs for On-farm trials with animals
Numerical examples
Discussion

A Manual for the Design and Analysis of On-Farm Trials

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