Training Workshop on On-farm Adaptive Research

20-21 June 1995

ISTI, Gannoruwa, Sri Lanka

Jointly Organized by

Field Crops Research & Development Institute
Department of Agriculture
Maha Illuppallama, Sri Lanka

And

Cereals and Legumes Asia Network
International Crops Research Institute
for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

Training Workshop on On-farm Adaptive Research, 20-21 June 1995
ISTI, Gannoruwa, Sri Lanka

Recommendations and conclusions

Introduction

The Workshop was jointly organized by CLAN/ICRISAT and Department of Agriculture (DOA), Sri Lanka at In-Service Training Institute (ISTI), Gannoruwa, Kandy. Participants were drawn from Department of Agriculture and Provincial Agricultural Offices involved in extension and on-farm research activities (List of participants is in Appendix 1). Four scientists from Sri Lanka (Drs.S L Amarasiri, K D S M Joseph, S M Somaratna and S A Abeysiriwardana) and three from ICRISAT Asia Center, India (C Johansen, C L L Gowda, and M C S Bantilan) were resource faculty to the course. The resource faculty discussed the needs for on-farm adaptive research (OFAR), concepts and techniques in OFAR, problem identification and prioritization, planning and implementation, and adoption and impact assessment of improved technologies. The papers presented are in Appendix 2 to 7.

On the second day of the workshop, the participants broke in to three groups to discuss:

- Identification of farmers' problems and constraints (Moderators: CLL Gowda and SLTD Bogahawatta).

- Adaptive research methodologies and planning of experiments (Moderators: C Johansen and Anula Perera).

- Research-extension-farmer linkages and adoption of technologies (Moderators: SM Somaratne and PB Dhamasena).

Recommendations

The recommendations were presented and discussed at the plenary session. The final recommendations are given below:

Identification of farmers' problems and constraints.

- Conducting surveys to identify problems perceived by the farmers was considered essential.

- In addition to formal surveys (such as PCT) other methods also could be considered. Informal surveys such as rapid rural appraisal (RRA) or participatory rural appraisal (PRA) should be used wherever formal surveys are not possible. All available secondary data should be collected from different sources.

- When we conduct a survey at the village level, the following information needs to be collected.

  - Ecological survey of village.
  - Climate, soil, rainfall, temperature, relative humidity, etc.
  - Socio-economic - Land holding size, upland/low land, irrigated/non irrigated, land tenure, food habits, off-farm income, etc.
  - Farming practices - Crops grown, extent, yield levels, livestock, water resources, cropping system, crop management practices, etc.
  - Infrastructure - Roads, credit, marketing, storage, processing, agricultural implements, communication, supporting institutions.
  - Demographic futures - Education level (Male/Female, Children/Adults)

(Note: Depending on the time and resources available, only essential information on climate, soils, farming practices, and socioeconomic data can be collected.)

- Surveys can consist of both group interviews and individual interviews.

- Problem Identification :
  - Identify the problems (Farmer perceived - researcher identified)
  - Analyze and define the problems using available data/knowledge
  - Priortize the problem based on
    - Farmer ranking;
    - Temporal and spatial occurrence, and yield loss; and;
    - Researcher ranking considering the above

- Identify possible solutions considering
  - Farmers indigenous knowledge
  - Researchers knowledge
  - Resolution of resource conflicts

- Who is involved in identification/prioritization :
  - Farmers / farmer leaders
  - Extension agents
  - Government Officers* / Agents*
  - Researchers (Multidisciplinary team)
  - Divisional Secretaries*
  - NGOs*

  (* for consultation / administrative purposes only)

Adaptive research methodologies and planning of experiments

Four steps involved in on-farm research are :

- Technology generation
  - Problem identification (described earlier) to seek opportunities intervention for technology transfer
  - Confirmatory trials to define problems and ascertain solutions
  - Finding remedies using on-station, and on-farm experimentation.
- Testing adaptability of solutions / technologies multilocationally in target areas.
- Socioeconomic assessment of the new practices compared to traditional practices.
- Demonstrations of the improved practices.

Table 1 gives details of the activities, experimental details, and persons involved.

Table 1 : Activity classification, experimental guidelines, and responsibilities in OFAR.

Activity	Site/ Location	Treat-ments	Replications	Plot size	Partners[1]	Management & Analysis/ interpretation
Technology generation	On-station and On-farm	Many	≥ 4	Small	F, R, Ex, Ec	Scientist
Testing adaptability	In different AEZs (No. of locations depends on resources)	≤ 4	≥ 2 and many locations	20-30 m^2 (depends on crop and spacing)	F, R, Ex	Situation specific (can involve all)
Socioeconomic assessment	Multilocation	2-3	1, but many locations/ fields	Large (depends on field size)	F, R, Ex, Ec	Farmer managed, with farmers' input
Demonstration	As many as possible	2	- do -	- do -	F, Ex (R, Ec)	Farmer managed

1 : F = Farmer; R = Research; Ex = Extensionist; and Ec = Economist

Research-extension-farmer linkages, and adoption of technology.

- Linkage is continuous, but is not adequate currently in Sri Lankan agriculture research-extension systems.

  Linkages involving the following need to be strengthened :
  - Regional Technical Working Group (RTWG)

- District Agricultural Committee (DAC)
- Research-Extension-Farmer dialogues
- Field days / Farmers days
- Seminars / Workshops
- Crop coordinator's meetings
- Varietal release committee

Links and functions are not clearly identified at present. Although RTWG is the nucleus, its agenda and role needs to be revised in terms of participation, documentation, and management of on-farm adaptive research, and the necessary linkages.

- CARP needs to coordinate research programs conducted by various agencies for avoiding duplication of efforts, competition for limited resources, and effectiveness of OFAR.

- Research - Extension - Farmer dialogue is not functioning properly at present, and needs to be re-initiated.

- Adaptive research program needs reorganization. Program needs to be re-initiated with clear objectives, and should formulate an adaptive research team (Research, Extensionist, Economist, and Farmers)

- Responsibilities of different partners in OFAR should be:

Research
- Generating technology
- Joint identification of farmers needs and problems
- Planning and implementation of planned research to address the needs farmers (through adaptive research with farmers)
- Participation in task forces activities
- Collaboration with other scientists among and within institutes.
- Systematic documentation of findings

Extensionist
- Transfer technology, and feed-back in farmers
- Joint identification, planning and implementation of research to address needs of farmers.
- Reporting of extension materials, and program monitoring
- Farmers' training and field days
- Working with farmers' organization and leadership development
- Assisting researchers in conducting on-farm trials
- Provide marketing information to farmers

- Provide marketing information to farmers
- Link farmer organization with other relevant organizations

Farmer organization / NGO's

- Assist in identifying field problems
- Cooperate in on-farm trials
- Disseminate information to other farmers
- Feedback on technological problems and constraints
- Develop seasonal planning for a whole range of crops with assistance of extensionists and other relevant agencies.

- Policy issues (of Government) needed to make OFAR efficient and effective:
  - Include farmers' organization representatives in RTWG,
  - Train village level manpower for extension activities,
  - Provide due recognition and resources needed for adaptive research activities.

- Assessment of adoption and impact of technologies
  - Socioeconomic analysis of technology by multidisciplinary group (Economist, Researcher, SMO, Farmers' Organization Representative)
  - Socioeconomic analysis of on-farm trials
    (data on cost and returns for alternative technology options inputs, yields, labour use, farmer preferences, constraints etc.)
  - Assessment of farmer acceptance and early adoption
  - Quantificaton of potential input of improved technology
  - Undertaking input assessment, institutional impact, environmental impact, etc.

LIST OF PARTICIPANTS AT THE WORKSHOP ON ON-FARM ADAPTIVE RESEARCH
20-21 June, 1995, ISTI, Gannoruwa

Name	Designation	Institute
M A Lateef	Deputy Director (R)	RARDC, Aralaganwila
L A Weerasena	Deputy Director (R)	RARDC, Angunakolapellesa
A Malima Perera	Research Officer	FCRDI, Maha Illuppallama
Susanthi Chandrasena	Research Officer	FCRDI, Maha Illuppallama
S Amarasiri	Director (HQ)	DOA, Peradeniya
S Abeysekera	Research Officer	RRDI, Batalgoda
K E Karunatilake	Deputy Director (E&C)	FCRDI, Maha Illuppallama
K G S Senaviratne	Research Officer	RARDC/Aralaganwila
M I M Rafeek	Aricultural Economist	RARDC/Aralaganwila
O S N Ekanayake	Research Officer	RARDC/Aralaganwila
T B Herath	ADA (IP)	Anuradhapura
H P Tilakarathne	ADA (IP)	Polannaruwa
W L B Ferdinando	Agricultural Instructor	ARU/Walpita
S J Aresakesary	Research Officer	FCRDI, Maha Illuppallama
K M A Kendaragama	Research Officer	FCRDI, Maha Illuppallama
K M Senivirathna Banda	Research Officer	FCRDI, Maha Illuppallama
A G K Gunavardhana	Agricultural Instructor	CPPD (Ag.)/Gatanke
S M K Dissanayake	Agricultural Instructor	CPPD (Ag.)/Gatanke
D M M Dissanayake	SMD (Agronomy)	PD's Office (NWP)
D T de S L Bogahawatha	Asst.Director of Agr.	ECC, Peradeniya
P B Dharmasena	Research Officer	FCRDI, Maha Illuppallama
R S K Keerthisena	Research Officer	FCRDI, Maha Illuppallama
H U Warnakulasooriya	Agricultural Economist	FCRDI, Maha Illuppallama
W M D H Kulatunga	Research Assistant	ARU/Matale
U Dissanayake	Research Officer	ARU/Moneragala
E R S P Edirimanna	Research Officer	FCRDI, Maha Illuppallama
W A P G Weeraratne	Research Officer	FCRDI, Maha Illuppallama
A H G Mithrasena	Research Officer	RARDC, Aralaganwila
N Kanthei Setunge	Research Officer	ARU, Pelmadulla
D M Weerasinghe	Aricultural Officer	PD Office, Badulla
P B L Premanath	SPD	SPD Office, Anuradhapura
C Wijesundera	Research Officer	RARC, Bombuwela
M Bogahawatta	Deputy Director (Ext.)	Ratnapura District
S Abeysiriwardena	Deputy Director (R)	RRDI, Batalagoda
M P Dhanapala	Director	RRDI, Batalagoda
S Parthipan	Research Officer	FCRDI, Maha Illuppallama
S M Somaratne	Chairman, Vegetable Task Force	Extn. & Communication Center, Peradeniya

contd..2/

Name	Designation	Institute
A R G Latheef	Deputy Director (Ext.)	Agriculture Department, Moneregala
K C M Bandara	Research Officer	ARC/Girandarakotte
R M Ranaweera Banda	Research Officer	FCRDI, Maha Illuppallama
K Hettiarachchi	Research Officer	FCRDI, Maha Illuppallama
G M W Chithral	Research Officer	FCRDI, Maha Illuppallama
C Johansen	Agronomist	ICRISAT, India
Cynthia Bantilan	Economist	ICRISAT, India
K D A Perera	Deputy Director (Research)	FCRDI, Maha Illuppallama
C L L Gowda	CLAN Coordinator	ICRISAT, India
K D S M Joseph	Director	FCRDI, Maha Illuppallama
K B Saxena	Resident Scientist/ICRISAT	FCRDI, Maha Illuppallama
Kamal Karunadasa	Lecturer	Faculty of Agr., Rahuna

Concepts and Paradigms in On-farm Adaptive Research[1]

C.L.L. Gowda
ICRISAT
Patancheru P.O., A.P. 502 324, India

Introduction

Transfer of technology was successful in the green-revolution era, where a set of 'package of practices' was applied in highly productive, homogenous areas with guaranteed irrigation, or assured rainfall. However, the success of these technologies has been minimal in the more diverse, less productive, and heterogenous area with inadequate irrigation or erratic rainfall. The 'top-down' approach where 'package of practices' developed in the well-endowed research stations (that were suited to resource-endowed farmers) were not suited to and hence not applicable to the diverse and less-endowed areas. Several reasons were forwarded as the cause of low adoption, but it was later argued that the problem was neither the farmer, nor the farm, but the technology itself and the priorities and processes of its generation (Chambers *et al.* 1989). This lead to several approaches of involving the farmers directly in on-farm research (the 'bottom-up approaches'). Some of these are:

- Farmer-back-to-farmer,
- Farmer-first-farmer-last,
- Farmers participatory research,
- On-farm client oriented research.

The central theme in all these approaches is the involvement of farmers. Farmers have been increasingly recognized as sources of indigenous knowledge and therefore should be involved in identifying needs and priorities and to use indigenous knowledge along with available scientific knowledge. As aptly put by Raintree and Hoskins (1988), "both scientists and farmers have unique areas of expertise which collectively produce better basis for development, than either alone".

[1]Paper presented at the "Training Workshop on On-farm Adaptive Research", 20-21 June 1995, ISTI, Gannoruwa, Sri Lanka.

On-farm research

On-farm research (OFR) refers to adaptive agricultural research conducted in farmers fields, with farmers' involvement. This should be viewed separately, but not exclusively, from the farming systems research, which encompasses a whole gamut of cropping systems, crop-animal interactions, etc.

OFR is location specific and takes into account the situation, needs, and priorities of the farmers as a starting point to plan and execute and adaptive research program. It either helps to adapt technology to the needs of the farmers, or provide support to further development of technologies that may have wider applicability. The cyclic nature and interaction of farmers, extensionists, and researchers are given in Figure 1.

On-farm research (OFR) versus on-station research (OSR)

Both OSR and OFR are important in the broader context of on-farm adaptive research. OFR and OSR are complementary and interdependent, and a balance of OSR-OFR is essential.

OSR -
- applied research, commodity-, discipline-, or factor-based, aimed at generating new technology components.
- scientists can manipulate variables in controlled conditions to seek answers.
- fundamental to quantify and test hypothesis.
- provide evidence of technical feasibility of an innovation.

OFR -
- adaptive research to modify available technology to suit the real farm situations.
- designed to increase research systems ability to respond to the demands and needs of client groups.

Types of farmer-implemented experiments

Based on researcher-farmer relationship, it can be (see Table 1 for details)

- Contractual,
- Consultative,
- Collaborative,

- Collegiate,

Problems associated with farmer-participatory experiments

- number of test factors needs to be small (one or two),
- degree of experimental uniformity is low,
- control of non-test management factors is difficult,
- monitoring of environmental variability is difficult,
- ability to draw statistically valid inferences reduces.

Any technology being tested for adaptation and/or adoption should be

- technically productive,
- economically attractive,
- socially acceptable, and
- environmentally sustainable.

Farmers' involvement in on-farm research process

Since it is important to involve farmers in on-farm research process, several approaches have been designed to have direct participation of farmers in:

- problem/constraint identification,
- identification of solutions (indigenous/scientific), and
- planning of experiments.

In this paper we will deal with characterizing the agroecosystems and identification of constraints with farmers' participation. The steps and procedures in constraint identification are given below.

Criteria for site (target area) selection:

- potential for rapid increase in production,
- should represent potential area for crop production,
- good accessibility (road, communication, etc.),
- cooperative farmers and supportive extension staff.

Diagnostic surveys (rapid rural appraisals) are used to:

- understand the agroecosystems and farming systems,
- identify superior practices followed by farmers,
- diagnose and identify problems and weaknesses in existing production and marketing systems,
- prioritize problems and identify solutions.

Information needed during diagnostic surveys:

- **Physical**: climate, soil, topography, etc
- **Biological**: pests, diseases, weeds, crop yields (reasons for low yield)
- **Management**: crop management practices followed and why.
- **Socioeconomic**: input/resource availability, land tenure, labor, credit, market systems.

Diagnostic survey interviews can involve:

- administrators, extension staff, village leaders, etc, and
- informal interviews with farmers.

Identified constraints could be grouped as:

- Socioeconomic (eg. lack of cash to buy inputs),

- Abiotic (eg. drought or water logging),
- Biotic (eg. pests and diseases),
- Management (eg. implements, etc.).

Once the constraints are identified, these need to be prioritized based on spatial (extent of area covered), and temporal (periodicity) occurrence of the problems, and extent of yield loss caused. After the prioritization, the researcher-extension-farmer group can plan the interventions/ experiments to alleviate the constraints.

References

Chambers, R., Pacey, A. and **Thrupp, L.A.** 1989. Farmer first: farmer innovations and agricultural research. London, UK: Intermediate Technology Publications Ltd.

Raintree, J.B. and **Hoskins, M.W.** 1988. Appropriate R & D support in forestry extension. Paper for the FAO Consultation on Organization of Forestry Extension, 7-11 March 1988, Bangkok, Thailand.

Table 1. Comparative attributes associated with five types of on-farm experimentation. (Source: Garrity, 1992)

Type	Conventional Replicated Experiments I	Farmer-Implemented Experiments II	III	Farmer-Participatory Experiments IV	Farmers' Informal Experiments V
Experiment designed by	Researcher	Researcher	Researcher	Farmer/Researcher	Farmer
Experiment managed by	Researcher	Researcher	Farmer	Farmer	Farmer
Experiment implemented by	Researcher	Farmer	Farmer	Farmer	Farmer
Attribute					
1. No. of test factors	Many	Few	1-2	1-2	Unlimited
2. Management uniformity of:					
o test factors	Uniform	Moderately variable	Variable	Highly variable	Highly variable
o nontest factors	Moderately variable	Variable	Highly variable	Highly variable	Highly variable
3. Potential complexity of the treatment	High	Low	Low	Very low	Very low
4. Analytical methods	Analysis of variance (AOV)	AOV or averages	Averages, regression	Convergence of observations, regressions linear programming	Convergence of observations
5. External information/ technology requirements	Usually high	Moderate	Moderate	Low	Low
6. Researcher-farmer relationship	Lessor-lessee; paid labor	Contractual or consultative	Partnership, collaborative	Advisory, collegiate	None
7. Rationale/ Justification	Establishes technical productivity Hypothesis testing High confidence in single factor performance Large numbers of treatments; low cost per treatment	Establishes realistic economic returns and farmer managerial feasibility	Greater farmer contribution to management than in II	Grants insights into fit of an innovation in farming systems Explores adaptive variation of an innovation	Contributes local innovation; results in spread of useful technology
8. Weaknesses	Questionable relevance to complex systems	Farmer innovation may be unrecognized or stifled	Across farm inferences weak	Weak cause-effect inferences and quantification	Experiential, non-quantitative, limited scope for technical

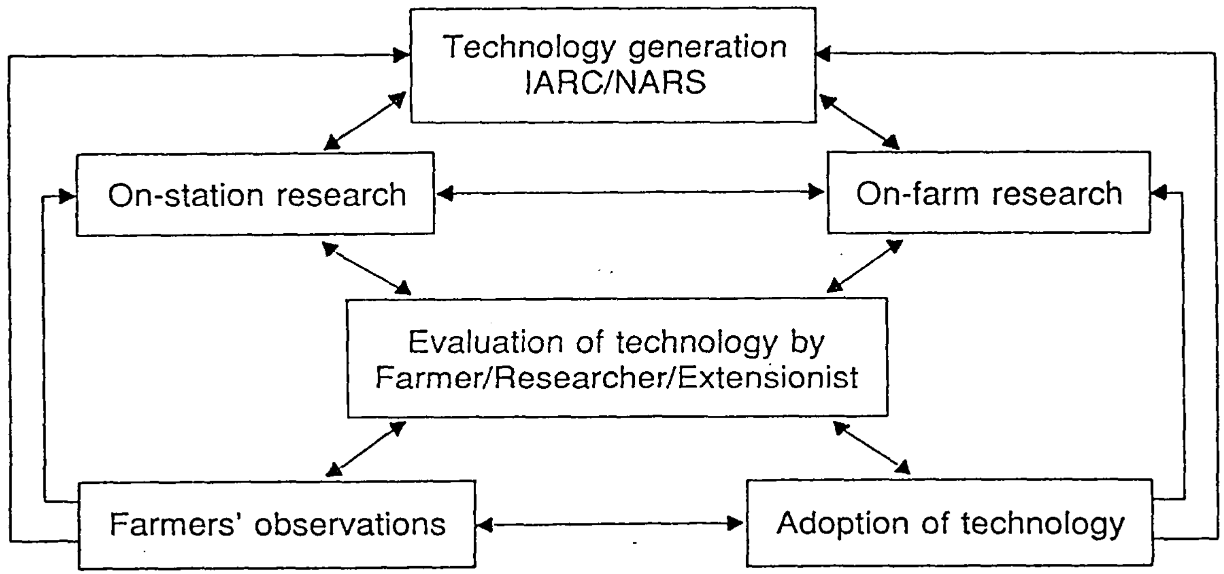


Fig. 1. **Model for Technology Adoption (Adapted from Denning 1985).**

Planning and Implementation of On-farm Adaptive Research[1]

C.L.L. Gowda
ICRISAT
Patancheru P.O., A.P. 502 324, India

Introduction

After site selection for undertaking on-farm research activities, diagnostic surveys are conducted to identify farmer-perceived constraints to production. These constraints are then prioritized by the team, considering the opinions and inputs from the farmers. The prioritized constraints are classified into: a) Socioeconomic, b) abiotic, c) biotic, and d) management related. Areas related to socioeconomics and policy (such as availability of credit, input, and price structure) are referred to the concerned administrative and government agencies for taking necessary follow up actions.

Planning of research

On-farm research planning:

- is a problem solving cyclic process,
- takes into account priorities of farmers,
- is sensitive to local needs,
- emphasizes on incremental changes/modifications,
- allows farmers to choose suitable technologies, and
- is a dynamic research process.

Production constraints differ across the target areas within a region or country. Therefore, planning of experiments should be done separately to address the identified constraints.

---

[1]Paper presented at the "Training Workshop on On-farm Adaptive Research", 20-21 June 1995, ISTI, Gannoruwa, Sri Lanka.

Types of on-farm research experiments

Although essentially all on-farm research experiments are to be on farmers fields, certain amount of backup and supportive research has to be conducted by researchers on-station. Some backup research (such as varietal development) may need to be planned as medium- and long-term endeavours to feed into OFR at later stages. Other on-station trials are needed to get quick confirmations or new information.

Four major streams of on-farm research experiments (Figure 1) have been listed by Garrity (1992).

- Researcher-implemented experiments -- scientists design, manage, and implement the trials in farmers fields.
- Farmer-implemented experiments -- experiments are designed and managed by researchers, but implemented by farmers.
- Farmer-participatory experiments -- farmer is involved in design, management, and implementation of experiments.
- Farmers' indigenous experiments -- farmers conduct their own experiments independently without collaboration with researchers or extensionists.

However, in most on-farm experiments a blend of all the above streams may be involved, depending on the circumstances of the research and the farm environment.

The type of on-farm research experimentation varies based on the level of information and technology available in a country. The could include: (a) exploratory single factor diagnostic trials where each factor (+ or -) is tested individually to assess its effect or performance (Table 1); (b) a series 'minus-one' experiments where the effect of a single factor among a combination of 3 or more factors is evaluated (Table 2); and (c) combination of proven factors/technologies that could provide synergistic effects (Table 3).

Care and precautions in on-farm research

- Number of variables/factors to be tested by farmers should be less.
- Control of non-experimental variables is important.
- Realize that farmers are likely to modify recommended technologies.
- A strong extension effort is needed to enhance adaptive research.

- Policies to ensure adequate supply of inputs (seed, fertilizer, chemicals).

- Availability of market and remunerative prices.

- OFR requires a degree of flexibility in research design and application of rigorous agricultural science, and exclusion of either is not likely to produce useful results.

- Farmers should have ample opportunities to interact with researchers and extension specialists for feed-back and modifications.

- Because of the degree of flexibility needed, researchers should be open to farmers suggestions, and the choice of strategies and methods depends on individual situations.

- Need for flexibility and rigour means that OFR results will not be quick (it may need 3-5 years before mature technologies are available).

Dissemination of technology

Once the technologies are ready for large-scale adoption, and dissemination, the researcher and extension agencies should take equal responsibility. Dissemination can be hastened by:

- Farmers' Days to disseminate the information.

- Training for local researchers and extension staff.

- Videos and pamphlets to increase awareness.

- Radio and television broadcasts.

- Farmer-to-farmer interaction and exchange.

References

Garrity, D.P. 1992. On-farm Research Methods in the Uplands: selecting an experimental approach. Rice Farming Systems Technical Exchange, 2 (3): 13-19.

Tripp, R. 1991. Planned Change in Farming Systems: Progress in On-farm Research. Chichester, UK: John Wiley & Sons.

Table 1. **AGLOR-Nepal**

Single factor diagnostic treatments for on-farm research in groundnut.

Treatment		Purpose: To determine/find
Seed dressing-	Fungicides	if seedling diseases are constraints
-	Insecticides	if soil insects reduce plant stand
Rhizobium inoculation		if pod yield could be increased
Irrigation		response in spring season
Seed rate		effect of plant population
Gypsum		role in pod filling and yield
Varieties		if new varieties are adapted

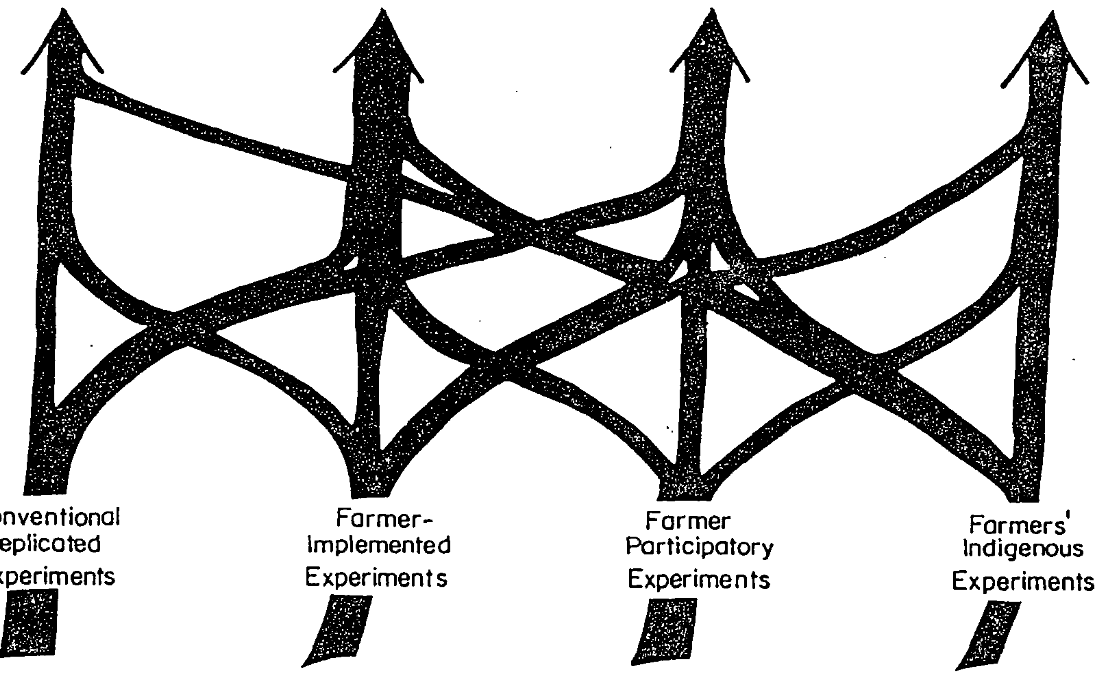
Table 2. A Plan for an experiment with 'minus-one factors'.

1. FYM + 40 N + 30 P + 20 K + Weedicide + Irrigation (F)
2. FYM + 40 N + 30 P + 20 K + Weedicide - Irrigation
3. FYM + 40 N + 30 P + 20 K + Irrigation - Weedicide
4. FYM + 40 N + 30 P + 20 K + Weedicide + Irrigation - 20 K
5. FYM + 40 N + 20 K + Weedicide + Irrigation - 30 P
6. FYM + 30 P + 20 K + Weedicide + Irrigation - 40 N
7. 40 N + 30 P + 20 K + Weedicide + Irrigation - FYM
8. Control

Table 3. Details of the farmers' practices and improved package of practices in on-farm research trials of groundnut conducted at Subang (West Java), late dry season (Jul-Sep), 1993.

Component	Farmers' practice	Improved package
Soil tillage	+	+
Seed bed	Flat	Bed (2 m)
Plant spacing	Irregular	20 x 20 cm
Sowing method	Dibbling	Dibbling
Seed dressing[1]	-	+
Fertilizers[2]		
Urea (kg ha^{-1})	-	25
TSP (kg ha^{-1})	-	50
KCl (kg ha^{-1})	-	50
Insecticide[3]	-	+
Fungicide[3]	-	+
Weeding[4]	Once	Twice
Irrigation[5]	+	+
Mean pod yield[6] (t ha^{-1})	1.30	1.72

1. Benlate® at 2 g kg^{-1} seed.
2. Fertilizers applied at sowing; TSP = triple superphosphate, KCl = potassium chloride.
3. Applied only as needed.
4. Twice by hand at 3 and 6 weeks after sowing (WAS).
5. At 7-10 days interval.
6. Significant difference ($P < 0.05$) compared to farmers' practice.



	Conventional Replicated Experiments	Farmer-Implemented Experiments	Farmer Participatory Experiments	Farmers' Indigenous Experiments
WHO DESIGNS:	Researcher	Researcher (with farmer input)	Farmer (with researcher or extensionist advice)	Farmer
WHO MANAGES:	Researcher	Researcher (with farmer)	Farmer	Farmer
WHO IMPLEMENTS:	Researcher	Farmer	Farmer	Farmer
EXAMPLES:	Fertilizer trials Variety trials	Cropping pattern tests	Hedgerow farming systems	New crops or cultivars

Fig. 1 The four major streams of onfarm experimentation. (Source: Garrity, 1992)

Workshop on Adaptive Research
In-service Training Institute, Ganoruwa, Sri Lanka
June 20 - 21, 1995

Identification and prioritization of Farmers problems and needs in Adaptive research

S.M.Somaratne

The way we perceive our environment, issues, people or events varies according to our understanding and relationship to them. To a layman a tomato is a tomato. or white rice is simply white rice. Not to the tomato grower in upcountry, however, who as a tomato grower can distinguish between many type of tomatoes. Or to a rice breeder who recognizes many types of white rice. Therefore, "seeing-the- world -through- different-eyes" fact of life.

And so it is, to a large extent, with agricultural scientists and developing country farmers (Rhoades, 1984). We are both engaged, in our own fashion, in the same objective: increasing the efficiency of agricultural production. Scientists strive to achieve this because it reflects the payoff of their research and farmers because it is their livelihood.

Eventhough, we must be honest and admit that agricultural scientists and farmers deal with different situation and conditions. And they see the world through different eyes. Our productivity, often measured by reports and publications directed toward other scientists or policy makers, is not the same as farmers productivity, measured by basic survival, family well being or increased family income.

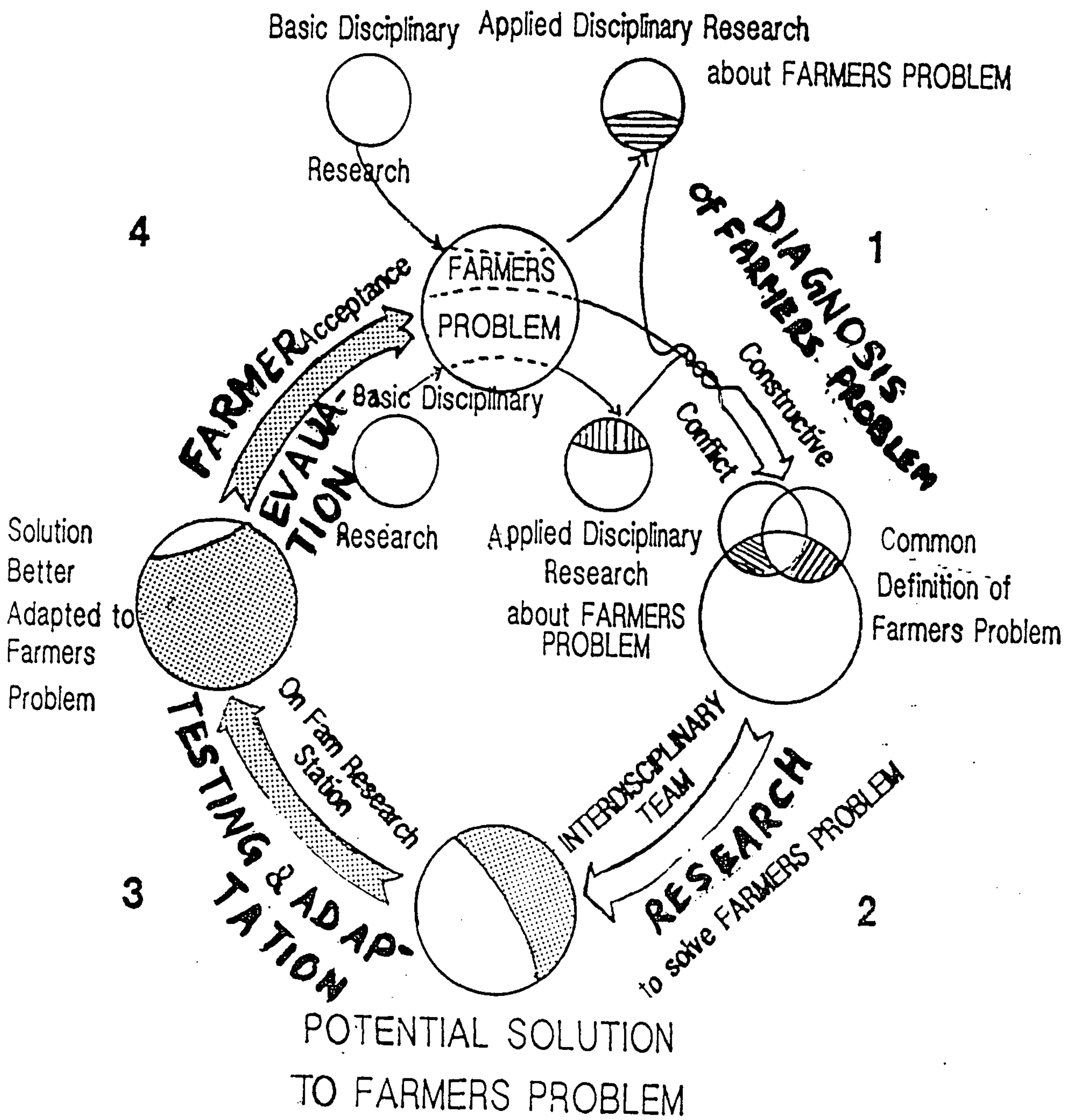
It an axiom that the farmers every where in the world recognize and reap the benefit of many kind of technologies developed through science. The challenge, therefore, is to bring farmers and scientist into meaningful communication in the technology generation process so that scientists are working on real problem rather than imaginary ones.

This is one basic reason for on-farm trails/adaptive research and actively bringing farmers into the research process. It helps scientists understand if their technology is appropriate to farmers conditions. Therefore, adoptive research is a learning process by which both researchers and farmers benefit.

Technology generation process

The burgeoning interest in the development and dissemination of appropriate technologies reflect the recognition of the essential role of technology in agricultural development particularly in developing countries.

In this venture it is important to understand the farmer and his conditions before designing



Farmer - Back - to Farmer

a model generating acceptable technology

any technology. It is also important to consider that available technologies may need to be subjected to "fine-tuning" before being adapted to a particular farming system.In this context, Rhoades and Booth (1982) and Chambers and Ghildyal (1985) suggested that in generating technologies farmers' collaboration with other disciplines throughout the whole process of identifying the problem, designing a probable solution and executing and evaluating the technology as an interactive interdisciplinary activity that would bring about an appropriate technology in an acceptable form. However, it is not possible to generate universal technologies which could operate everywhere equally well as expected.

This interdisciplinary relationship as shown in the conceptual model, does not terminate at the technology development stage but it is a continuing activity even after the subsequent sustained adoption process.

It is also necessary that these technologies reach the end-user if they are to be put into practice. There are a number of different sources of agricultural information and different means and strategies for disseminating these information to end-users. During this process farmers may further evaluate and adapt different technologies in various aspects in order to fit them into their setting. However, farmers' objectives in adopting new technologies are more complex than increasing production.

Diffusion of technologies over time had been viewed as aggregate outcome of many decisions taken by an individual. Individual decisions to adopt a certain technology may be influenced by several factors, namely: social, economic, psychological and physical.

Therefore, testing of technologies at the farmers' level is an important component of research process especially in developing countries where communication link between farmers and research is weak. Farmers often do not possess adequate information and competencies in combining or modifying the technological changes to their own environmental and production system.

Adoption of a new idea is the consequence of a series of human relations. Therefore, insights unto the nature of interaction and communication flow between and among the farmers and other disciplines involved in technology generation and dissemination would help in understanding the diffusion and adoption process in a farming system.

Methods of Problem Identification

1. Interact with farmers/ key informants/ local institutions/NGOs
2. Joint field visits and personal observation
3. Extension -research -farmer dialogues
4. Systematic need assessment
4. Concept mapping
5. Random checking
6. Secondary data/ reports/publications/and news

7. Multidiciplinary group activities
8. Rapid rural appraisal
9. Farming system research and extension

Problem analysis phase deals with:

- Possible causes
- Constraints
- Present practice
- Use of recommendations and their effectiveness
- Monitoring of the problem
- Potential impact of proposed technology
- Long term effects of the technology

Definition of the problem

Logical analysis of the farmers problem gives a guide line to what is to be research. Therefore, clear definition of the problem is an essential requirement before we design adoptive research.

Seven Key Questions in the Farmer Evaluation of Adoptive research

To help us understand small farmers we can ask them and ourselves the following seven basic questions regarding on-farm research:

1. Is the problem to be solved important to farmers?

2. Do farmers understand the trials?

3. Do farmers have time, inputs, and labor required by the improved technology?

4. Does the proposed technology make sense within the present farming system?

5. Is the mood favorable for investing in certain crops in a region?

6. Is the proposed change compatible with local preferences, beliefs, or community sanctions?

7. Do farmers believe the technology will hold up over the long-term?

In asking these questions --all of which are common sense but often forgotten in the process of on-farm research try to "think like a farmer". If you were in his place, given his circumstances and resources, how would you view the trials and technology being proposed. Remember a simple rule of thumb: the farmer is the teacher, "the expert" about local farming practices and you are the learner. Fight off the urge at this point to be the all-knowing adviser.

Prioritization

Often we judge the performance of a proposed technology by using agronomic evaluation criterion: yield increase, resistance to pest and diseases, growth etc. However, in farmer evaluation, agronomic evaluation represents only part of the complex decision making process. He will ask several questions himself : Will the proposed adoptive research addresses a problem he considers to be important? Whether the technology conflict with other activities in the present farming system? How important is the risk inherent to its adoption? If additional inputs are required for its adoption, is it feasible within his resource base?

In summary, adoptive research should prioritized as much as possible using following basic criterion

1. Significant impact on the production, utilization, or marketing by adopting the proposed technology.
2. Opportunities for efficient and effective resource utilization of the farmer.
3. Adopting existing solutions to farmers problems rather than developing new technologies (comparing a given alternative to the present crop production system of a target group in a targeted area)
4. Cost-benefit analysis.
5. Carry a good potential for adoption which makes them eligible for transfer to the diffusion channels available.

References

Rhoades, R.E. 1984.Understanding small farmers in developing contries: sociocultural perspective on agronomic farm trails. Journal of Agroomic education , Vol.13, Spring p.64-68.

Rhooades, R.E. & R.H.Booth.1882. Farmer -back-to-farmer: A model for generating acceptable agricultural technologies. Agricultural administration Vol.II P.127-137.

Chambers, R.J.H. & B.P.Ghilyal 1985. Agricultural research for resource poor farmers: the farmer-First- and -last model. Agricultural Administration, Vol. 20 p 1-30 .

FROM RESEARCH STATION TO FARMER RECOMMENDATIONS: AN AGRONOMIST'S VIEWPOINT

K.D.S.M. JOSEPH

Introduction

Considerable effort has been made during the last few decades to develop new varieties and technologies to increase the production and productivity of many crops. With these changes, predictions of self-sufficiency in food production for most of the developing countries were common. In favourable environments, the modern technology has increased yields of several crops. However, the agriculture in many asian countries is characterized by small land holdings, diverse environmental conditions and capital poor farmers. Therefore, the rate of adoption of modern technology has varied greatly between countries, between areas within countries and among different crops.

The main objective at initial stages of technology development was to increase the national food production of these countries and thereby to improve the economic conditions of the farmers. Eventhough, they have succeeded in achieving near self-sufficiency in some of the food crops, the economic level of these farmers who cultivate these crops still remains same or in some cases, it is worse than before. Moreover, the adoption of new technology by farmers in many developing countries still remains low due to various reasons.

It is now clear that development of modern technology alone, however, may not increase yields and productivity. The technology must be tested in farmers fields and any constraints for adoption by farmers need to be identified. In many cases, the technology generated in research stations were commodity based or discipline based and needs high inputs and good management. Capital poor farmer is unable to cope up with these situations. Also, in developing technologies, small farmer situations were not thoroughly analyzed. In many cases researchers were unaware of the farmers goals and their socio-economic environment.

History and Present Status of Adaptive Research in Sri Lanka

Literature indicates that testing of new technology in farmers fields in Sri Lanka started during the early part of this century when pure line selections of traditional varieties of rice were tested in farmers' fields in several locations of the country. However, at that time the research activities were confined mainly to Peradeniya (Kandy) because no agricultural research stations were operating in other parts of the country. These tests in farmer fields have helped the researchers to select several pure-line selections of rice which have helped to increase rice yields in Sri Lanka. During 1960's and early 1970's, where old improved rice varieties were introduced (the 'H' series varieties), the FAO/Freedom From Hunger Campaign initiated a national fertilizer testing/demonstration programme in farmers' fields. The main objective of this programme was to check the fertilizer response of 'H' series rice varieties in different parts of the country. With the termination of the project the work continued, but in a smaller scale, with the formation of Field Trials Division of the Department of Agriculture.

In late 1970's, the Agricultural Extension and Adaptive Research Project was started and Adaptive Research Centers were establishered in each district of the country. The objective of this programme was to identify farmers problems and research needs and also to initiate on-farm research programmes in collaboration with the extension staff. However, this was not a successful programme due to various reasons and some of then are:

- Centres were located away from research and extension centrers, and as a result there was hardly any interaction between research and extension during the day to day activities.

- The officers in-charge of these centrers did not have adequate experience (newly recruited officers) and were not in a position to identify the complex situation of the existing agricultural system/socio-economic situation.

- Multi-disciplinary approach was lacking and the participation of the extension staff in these activities was poor.

This workshop was primarily motivated by the facts that yields of Other Field Crops (OFC's) in farmers fields are much lower than those obtained at research stations and the level of adoption of new technology by the farmers are not to the expectations. The need to develop suitable mechanisms and methodologies to test new technology emerging from research centres has become an immediate necessity.

Successful Farm Recommendations

Adequate technical information alone is not sufficient to make good farm recommendations. These information should be consistent with farmers' goals, and researchers should be aware of the constraints on attaining these goals. Moreover, we have to be aware of the human element of farming. The issue of development of new technology and understanding of farmers constraints must be addressed together, if we are to expect greater adoption of these technologies.

The process of on-farm testing of technology can be considered at three stages (Fig. 1). The initial testing will help the researcher to understand the adaptability of the technology to a given physical/biological environment. As these environments are different from those in research stations, the researcher will get an opportunity to modify his technology to suit the

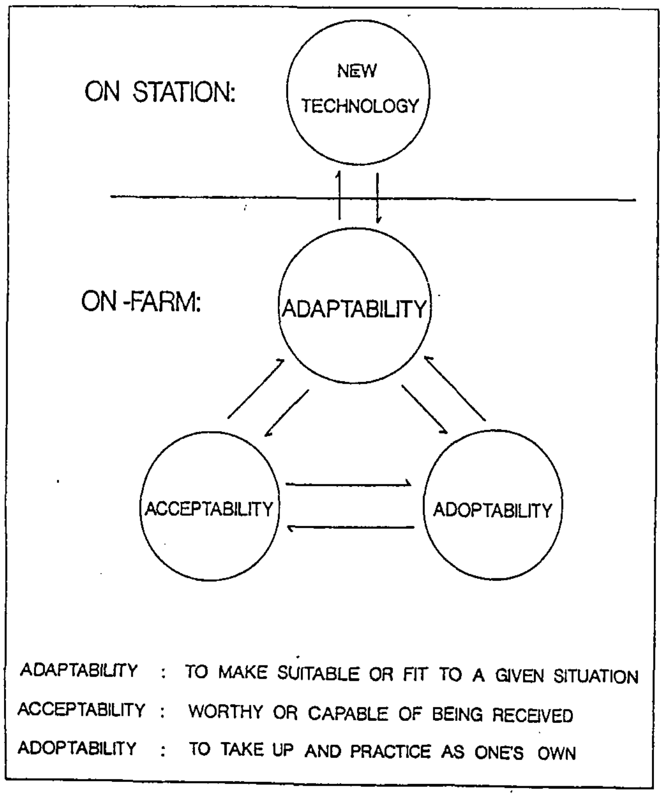


Fig. 1. Process of on-farm testing of technology.

environment. When researcher finds that the technology is adapted to the environment, it may be accepted by the farmers if they see that their goals can be met by the new technology. For example, in these testing programmes if a new variety produces yields higher than what is being grown, the farmers will accept this variety as a high yielder. However, acceptance of technology does not mean that the farmer is going to adopt it. For farmers to take up and practice as one's own, the constraints to adopt them needs to be addressed.

The constraints in achieving experiment station yields by farmers are two fold and Herdt and Barker (1977) has explained these constraints (Fig. 2). In this model, Gap I, identifies the difference between the research station yields and potential yield in farmers' environments. This is called the "environmental effect". It is well recognized that the yield of any crop varies considerably from location to location and from season to season. Much of the variation in yield is caused by climatic and soil factors over which farmers have little or no control. These factors cannot be ignored by researchers and treated as random variations in statistical analysis. Moreover, this variation is often greater than that caused by treatments in many field

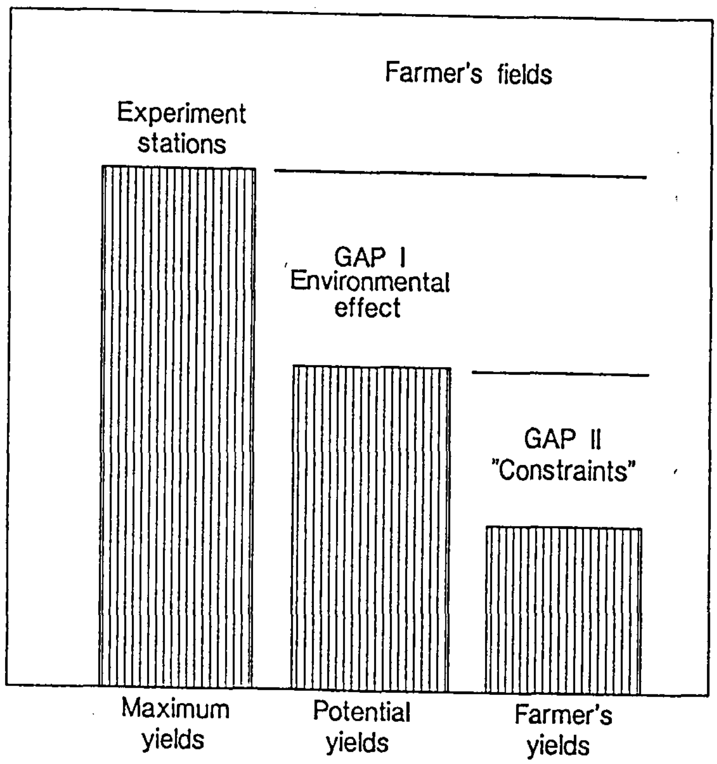


Fig. 2. "Two-Gap" Model for yield difference. (Herdt and Baker, 1977).

experiments. Therefore, the effect of climate and soil factors cannot be overlooked. During the first phase of the on-farm research the objective should be to identify the shortcomings of the technology and modify to suit to the growing environment. This will help to reduce the variation due to environmental effects.

Gap II shows the difference between farmers' actual yields and the maximum potential under their conditions. Gap II, identifies mainly socio-economic constraints in achieving actual farmer yields. Once you find that the technology is adapted to the environment, a better understanding of socio-economic constraints and ways to overcome at least some of the constraints is required in order for the farmer to adopt the new technology. Therefore, interdisciplinary studies to understand both technical and socio-economic constraints are required to make a successful farm recommendation.

To initiate a successful on-farm adaptive research programme following could be proposed for discussion during the workshop:

1. Problem identification and prioritization is important. Both specific problems as well as issues that reduce yields in farmers fields needs to be addressed in planning adaptive research programmes.

2. Socio-economic assessment of the situation is essential. In many situations, farmers' objectives are different from researchers' and farmers do not attempt to maximize yields. What they need is optimum yields/income for the resources used in the production process. Therefore, economic evaluation of new technology must be an integral part of adaptive research programmes. However, this evaluation is a complex process and simple methodologies needs to be identified.

3. Multidiciplinary approach is an essential component of adaptive research programmes. Not only researchers from different disciplines, but extension staff and farmers should participate in all on-farm research activities. They should form "adaptive research teams" in different farming situations and this team should be involved in planning, conducting, and technology evaluation processes.

4. After identifying the research needs it is also important to develop methodology for adaptability testing of new technology. It is often asked by researchers and extensionists that what should be tested in on-farm trials?, how is the programme for a season is developed?, who is responsible?, what are the target group?, who is responsible?, and at what management level? etc..

It is essential that during this workshop we discuss these aspects and come out with recommendations that would help us to implement an effective adaptive research programme. An effective on-farm research programme should indicate not only the yield advantage of new technology but also what factors contributes to the increase in yield. In addition, answers to the following is important: Is the new technology more profitable than what farmers use now?. If the technology is not suitable, what factors restrict yields?. This will provide feedback to researchers and enable them to modify the technology.

References

Herdt, Robert W. and Randolph Baker., 1977. Multisite tests, environments and breeding strategies for new rice technology. IRPS No. 7 IRRI, Philippines.

Technology Adoption and Economic Assessment of On-farm Adaptive Research

Ma. Cynthia S. Bantilan[1]

Introduction

On-farm adaptive research (OFAR) strategy targets its impact on farmers' fields. It ensures that farmers' points of view (including an understanding of farmers' conditions and problems, their priorities, and their criteria in adopting or rejecting new technologies) are represented in the research agenda.

OFAR introduces a package of technology or components of a package (e.g., new variety, equipment, cultural practices or techniques that result in more productive and better quality crops) or information including those that facilitate the acceptability and adoption of these technologies. The impact or potential impact of research effort is evaluated in terms of the extent to which welfare gains are achieved by farmers and other sectors of society.

The long-term and dynamic nature of OFAR demands mechanisms for periodic and systematic evaluation. Assessments are undertaken ex-ante (during research planning) to evaluate potential benefits; and ex-post (after research) to assess adoption and impact. During project implementation, a combination of ex-post and ex-ante assessment is useful to monitor refinements in research implementation and technology development. As in any other investment, planned assessments are important to rationalize choices among alternative research options and to provide a stronger basis for accountability and for decisions on research resource allocation.

This paper presents a general framework for agricultural research evaluation. This framework is discussed in the context of OFAR, featuring the key role of product acceptability and technology adoption. Two general approaches of measuring impact are described. A list of information variables (including technical and economic data) required for impact assessment is presented, citing some examples.

General Framework for Research Evaluation

Three main phases characterize the general framework for research evaluation. The framework starts with the consideration of research investments that fund the imple-

1. ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

mentation of research projects (Phase 1). The new knowledge and technology generated are expected to bring forth changes in the production and the consumption environment (Phase 2) as more and better commodities become available in the market as a result of the utilization of the new technology. To be more specific, the application of science-based technologies in agriculture is expected to bring about increases in crop yields, more palatable grains, bigger seed size, higher fodder yield, increase in average daily weight gain of poultry, and higher average litter size of livestock. Research is also expected to improve the efficiency of various inputs including management. Ultimately, the above changes in the production and consumption environment translate into increased welfare of the society (Phase 3).

Before the benefits of research ultimately accrue to the members of society (i.e., producers and consumers), three important conditions must be met. First, the research undertaken must be successful in achieving its targeted objectives. This introduces the notion of probability of success or relative research capability. Second, the potential increase in production promised by a new technology is ultimately achieved only when the technology is adopted by farmers. This condition necessitates the consideration of the rates of technology adoption and the factors constraining it. Third, the measurement of the welfare gain to society is incomplete if it does not take into account the externalities (both positive and negative) which the technology involves. This paper focuses on the critical role of the second condition (i.e. adoption) in achieving welfare change of the researchers' ultimate clientele — society. The first and third conditions have been considered in detail by Bantilan and Davis (1991a, 1991b).

Consideration of research evaluation in the context of OFAR provides an opportunity to feature the adoption phase as this type of research primarily aims to (1) improve the acceptability of technologies; and (2) facilitate the adoption of technologies. In this case, the following adoption-related variables are highlighted: adoption lags, rate of adoption, and ceiling level of adoption.

A typical adoption curve is given in Figure 1. Introduction of a new technology is not usually met by immediate adoption. The gestation period between the generation of a technology and its adoption varies by sector, commodity, and even types of technologies. There are farmers who adopt technology almost immediately while other farmers have a wait-and-see attitude and adopt only after the effects have been convincingly demonstrated. Reluctance among farmers to adopt a technology may be due to market uncertainty, price fluctuations, preference for specific grain qualities (e.g., large seed size), preference for very low management crop technology, etc. Thus, a sigmoid adoption curve is usually used to illustrate the adoption process where level of adoption is initially low, rises at an increasing rate after some sufficient diffusion is attained, and finally reaches a ceiling level of adoption. Adoption lag refers to the time interval between introduction of technology to attainment of the ceiling level of adoption.

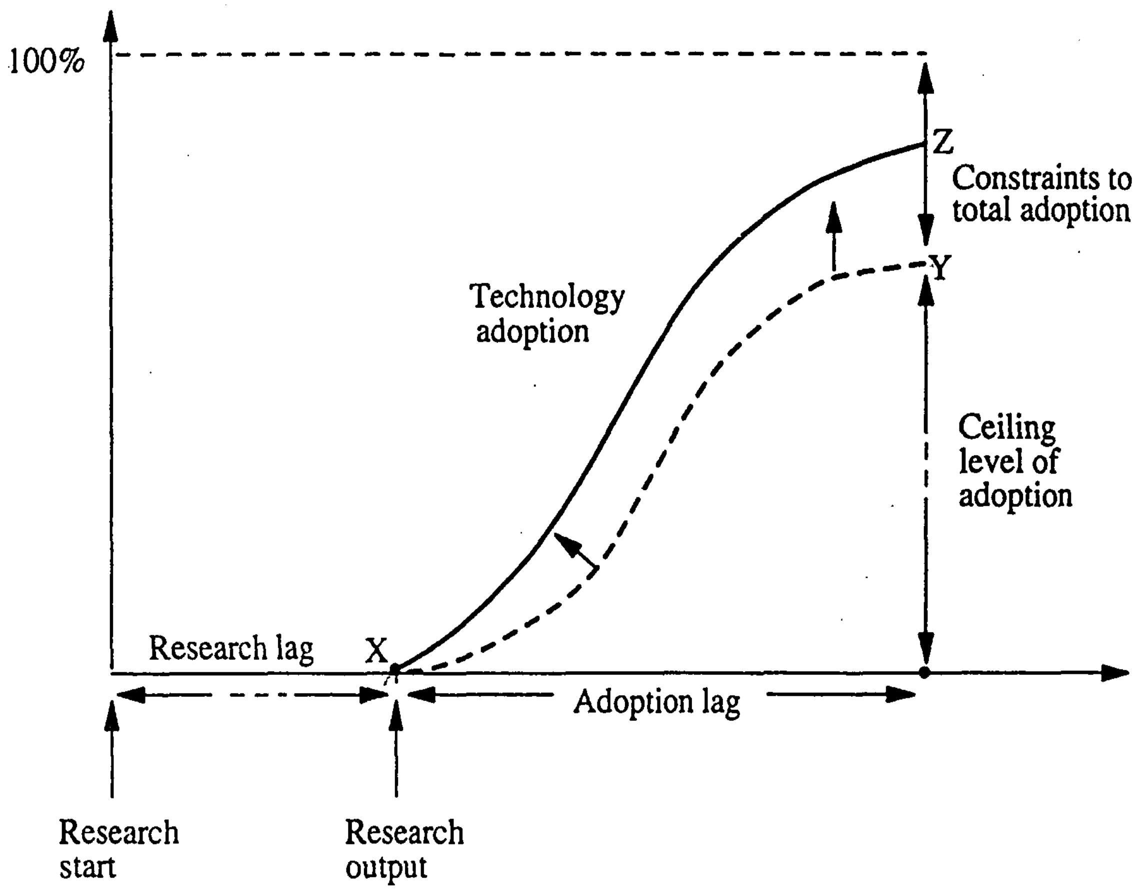


Figure 1. A typical technology adoption curve.

Conceptually, the impact of OFAR may be measured by the extent to which the adoption curve is pushed upwards (from XY to XZ, as shown in Figure 1) as information feedback through OFAR accelerates technology adoption, given the structure (extension, market, roads, etc.) of the location considered. Aside from OFAR, several factors like good extension network, processing structures, road infrastructure, and assured market enhance technology adoption. Measurements of the level and extent of technology adoption compound the contributions of all these influencing factors. Thus, analysis of technology adoption due to each factor requires subsamples involving homogeneous structural environments.

Measurement of Economic Impact of Research

Impact assessment involves three basic steps: (1) choice of evaluation framework; (2) generation of information about current and new technology; and (3) estimation of welfare gains from the use of the new technology.

The choice of an evaluation framework has been the subject of extensive enquiry. Two approaches in assessing the welfare gains from research are commonly used. The first measure, i.e. the value of the increase in output, relies on estimates of the expected change in output due to research valued at the current or expected commodity price. The second measure, more commonly referred to as welfare-theory based measure, uses the principle of economic surplus to measure the size and distributional consequences of research-induced technological change. Both approaches utilize the basic concepts of demand and supply in representing the production and consumption environment.

Substantial differences can occur between the two measures. Consideration of stability of estimates under uncertain demand and supply conditions favors the use of the second measure. Nevertheless, a good understanding of the underlying production and consumption environment is required in choosing an appropriate measure and in interpreting the estimates.

The net benefit from the research effort is computed by subtracting the actual research costs plus additional costs involved in the use of the new technology and accounting for the extent to which the technology is adopted by farmers. As the benefit due to research accrues for several years, the string of benefits is expressed in terms of its present value.

Refinements to the above simple approach have expanded the framework to incorporate spill-over effects of research across locations/commodities, multi-regional trade, and government intervention.

Measures of Profitability of Component Technologies

Complementing the methodology presented above are two useful techniques for identifying profitable component technologies: (1) use of partial budgets; and (2) marginal analysis. Partial budgets are used to identify economically viable or profitable technologies by comparing changes in costs with corresponding changes in benefits. A component technology is said to be more profitable than another when the increase in benefits due to a component technology outweighs the corresponding increase in cost.

Marginal analysis identifies the most profitable component technology as one with the highest net benefit with a marginal rate of return (MRR) greater than the minimum rate acceptable to farmers, where MRR is computed for each adjacent pair of treatments, i.e.,

$$\text{MRR} = \text{change in benefit cost/change in variable cost} \times 100.$$

Data Elements for Impact Assessment Work

The basic information required to apply the 'value in output change' approach are: (1) change in level of production; (2) output price; (3) research cost; and (4) adoption level.

To utilize the welfare-theory based measure, the following minimum data set is needed: (1) change in production and yield levels; (2) price and cost of production; (3)research cost; and (4) adoption level.

Information about changes in farmer's practices (e.g., crop rotation) and the resource base (e.g., soil characteristics, erosion index, water quality, and soil fertility) are complementary information that allows an evaluation of changes that may be attributable to technology adoption.

Examples of Evaluation

Example of evaluation for a component technology (marginal analysis) is given in Table 1 and for crop improvement/management package (welfare theory-based measure) is given in Table 2.

The results in Table 1 indicate that the application of basal lime is most profitable, capturing most of the net benefits at a much lower cost. Analysis of the cost structure in Table 2 shows that the variable costs per hectare are substantially lower before research as opposed to after the technology is developed and adopted. Despite this, with the very large yield increase from 7.5 to 35 t ha^{-1} it is found that the unit cost of production is reduced substantially, by approximately 50%.

Further analysis of the farmers' cost structure given in Table 2 can be made by considering some assumptions on research and adoption lags of 9 years and an adoption pattern to provide an estimate of the benefits from the research. This assumption considers that the availability of the new technology results in 3 additional years of staggered adoption so that it is likely to be 12 years before all farmers have replaced the old practice. Once all components are accounted for, including the cost of research and an 8% discount rate, the total benefit from research is estimated to have a present value of $2.9 million. The internal rate of return for this situation is approximately 20%, indicating a relatively high payoff.

Table 1. Split application of lime: marginal rate of return.

Input/output parameters	Treatment: No lime	Basal lime at 250 kg ha^{-1}	Basal lime at 250 kg ha^{-1} and dressing lime at 250 kg ha^{-1}
Yield (kg ha^{-1})	1210	2530	2870
Gross field benefit ($) (Farm Gate price = $.30 kg^{-1})	363	759	861
Cost of lime ($)	0	7.50	15.00
Cost of labor for lime application ($)	0	1.50	2.50
Total variable cost ($)	0	9.00	17.50
Net benefit ($)	363	750	843.50
Net benefit increment	-	387	94
Variable cost increment	-	9	8.5
Marginal rate of return (%)		43	11

Table 2. Cost structure of research impact analysis for crop improvement/management research.

Output/Cost	Unit price (Rs)	Before research Quantity	Before research Cost (Rs)	After Research Quantity	After Research Cost (Rs)
Variable costs ha^{-1}					
Labor					
Land preparation (days)	85.58	35.0	2995.3	35.0	2995.3
Planting (days)	85.58	6.0	513.5	6.0	513.5
Weeding (days)	85.58	12.0	1027.0	24.0	2053.9
Irrigation (days)	85.58	2.0	171.2	10.0	855.8
Fertilization (days)	85.58	1.0	85.6	5.0	427.9
Spraying (days)	85.58	0.0	0.0	15.0	1283.7
Harvesting (days)	85.58	50.0	4279.0	80.0	6846.4
Hauling, grading, packaging (days)	85.58	25.0	2139.5	36.0	3080.9
Fertilizer (50 kg)	400	1.0	400.0	15.0	6000.0
Pesticide (bottle)	300	0.0	0.0	5.0	1500.0
Seeds (gm)	10	0.0	0.0	30.0	300.0
Packaging materials			200.0		7500.0
Miscellaneous (plastic bags, etc.)			0.0		5000.0
Equipment/animal labor					
Land preparation (days)	100.00	27.0	2700.0	27.0	2700.0
Hauling, weeding (days)	100.00	25.0	2500.0	25.0	2500.0
Transportation	22	2.0	44.0	5.0	110.0
Total variable costs			17055.0		43667.4
Fixed costs					
Owned land: rental value, tax	5	378.0	1890.0		1890.0
Land rent: lease rental	1	725.0	725.0		725.0
landlord share	5	289.0	1445.0		1445.0
Depreciation and interest on capital	1	399.0	399.0		399.0
Total fixed costs			4459.0		4459.0
Total costs			21514.0		48126.4
Output ha^{-1} (t)		7.5		35.0	
Change (%)				366.7	
Unit cost assessment					
Unit variable cost			2274.0		1247.6
Unit fixed cost			594.5		127.4
Unit total cost (Rs t^{-1})			2868.5		1375.0
Unit cost reduction					
Unit variable cost reduction					1026.4
Unit fixed cost reduction					467 1
Unit total cost reduction (Rs t^{-1})					1493.5
Unit cost reduction (%)					52.1

References

Bantilan, M. C., and Davis, J. S. 1991a. Across-commodity spillover effects of research and opportunity costs in a multi-product production environment, ACIAR/ISNAR Project Paper no. 30, Philippines Country Study. Canberra, Australia: Australian Centre for International Agricultural Research/The Hague, Netherlands: International Service for National Agricultural Research.

Bantilan, M. C., and Davis, J.S. 1991b. Research production function and probability of success in agricultural research evaluation. ACIAR/ISNAR Project no. 31, Philippines Country Study. Canberra, Australia: Australian Centre for International Agricultural Research/The Hague, Netherlands: International Service for National Agricultural Research.

Use of Environmental Information Systems in Analyzing Crop Adaptation and Production Constraints as an Aid to On-farm Research

C. Johansen

Introduction

A focused research and development program for a crop or cropping system should be based on a comprehensive analysis of the relevant database for the target region. This database should comprise production and area trends, and factors affecting production including biotic, abiotic, socioeconomic, and utilization constraints. The information should be presented as clearly as possible in order that it may be adequately interpreted by a wide range of persons, including nonspecialists. The recent development of geographical information systems (GIS) — computer-based packages which allow rapid plotting of large data sets as digitized maps — is a great help in this area. GIS packages were originally developed for land-use planning to depict mainly geographical features such as soils, water courses, administrative boundaries, vegetation pattern, etc. However, for crop research it is also necessary to plot climatic factors, incidence and extent of biotic and abiotic constraints, and socioeconomic factors. Among researchers concerned with crop adaptation and interested in exploiting GIS technology, the terminology of 'environmental information systems' (EIS) is being increasingly used, as this more comprehensively describes what is plotted.

At ICRISAT, we had earlier attempted mapping production zones and production constraints of groundnut, chickpea, and pigeonpea crops in various Asian countries but without the aid of EIS. Results of this manual cartographic exercise are presented in an ICRISAT Research Bulletin (Virmani et al. 1991), which proved to be a useful base line of knowledge available up to the end of the 1980s. But it was a laborious and time-consuming exercise.

We therefore established an EIS facility. In a collaborative exercise between the International Center for Agricultural Research in Dry Areas (ICARDA) and ICRISAT, EIS is being used to plot out the factors affecting adaptation and production of chickpea in the West Asia and North Africa (WANA) region. We are thus in the process of adapting EIS to answer questions concerning crop adaptation.

1. ICRISAT Center, Patancheru, Andhra Pradesh 502 324, India.

The purpose of this paper is to briefly describe the use and potential of EIS in understanding crop adaptation and in research prioritization. We are beginning an EIS study of adaptation of groundnut in Vietnam, which we will draw upon to illustrate the application of EIS to crop research and development.

Description of EIS

A landscape is composed of many components: land resource base, vegetation, man-made boundaries, climatic factors, etc. The advent of computers with large memories has allowed digitization of such data sets in the form of individual map layers by using EIS technology. Existing maps can be directly digitized on digitization boards, whereby boundaries are reproduced on the computer screen on the basis of grid points. Different map layers can be instantaneously superimposed so as to help in understanding better the relationships between them. This procedure can also be done by standard cartographic means but slowly, laboriously, and with a high probability of transcription errors.

The scale of the landscape may vary from global to farm size. For example, at ICRISAT we have been using global plots of crop distribution in relation to various factors to set research priorities for our mandate crops on a global basis. At the other extreme, we use an EIS system for database management of the ICRISAT research farm. But mostly we work at the level of a country, or a region within a country, to understand crop adaptation.

Use of EIS for Groundnut in Vietnam: a Case Study

Since 1976, the area, production, and yields of groundnut in Vietnam have shown an increasing trend (Fig. 1). To establish the primary production zones of the crop, we plotted the area distribution on a provincial basis (Fig. 2). In Vietnam, the number of provinces is sufficiently large so as to adequately delineate country-wide distribution of the crop. Greater precision can be achieved by plotting out district data (e.g. for a portion of the country), but we first attempted a countrywide overview. There have been some changes in provincial boundaries in recent years and this complicates display of the time trends. Where changes have occurred, district-level data are required to accurately represent production changes over time. Figure 2 indicates where the increases in area have occurred between 1976 and 1990, mainly uniformly across the country. In 1976, groundnut yields were highest in some southern provinces. In 1990, yields generally increased in southern provinces and in the Red River Delta area in northern Vietnam (Fig. 3).

We are examining these production data in relation to various environmental factors (data are being assembled and digitized). For the information on soil, we will use the FAO-UNESCO soil map of the world. The major climatic factors to consider are soil-water status and temperature. For groundnut grown in seasons other than the

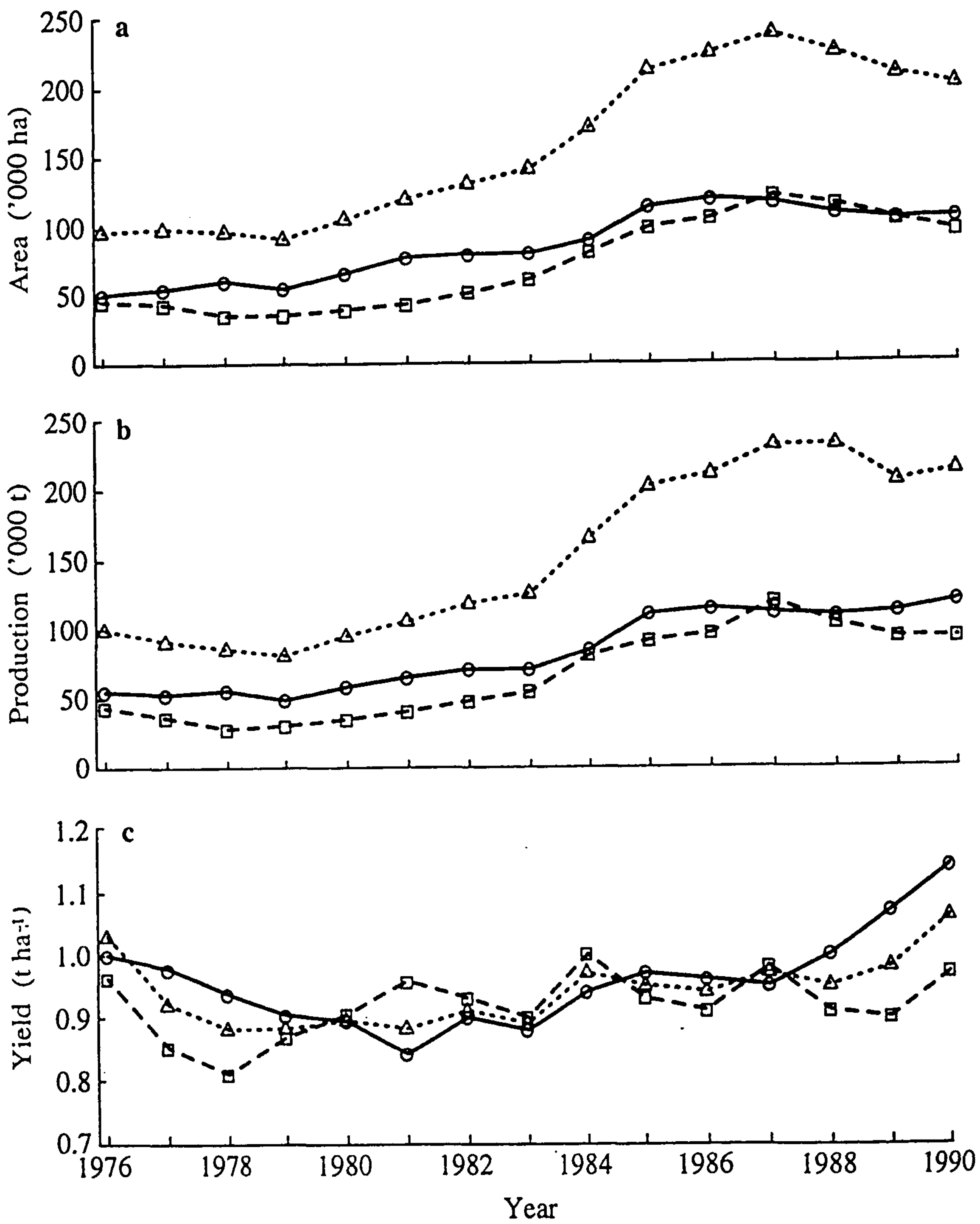


Figure 1. Trends in (a) area, (b) production, and (c) yield of groundnut in southern (o), northern (□), and total (Δ) Vietnam from 1976 to 1990.

rainy season, as is normally the situation in Vietnam, isohyets for total rainfall may not be of value in interpreting groundnut adaptation. It is thus necessary to establish and map the mean soil-water balance during the cropping season, based on rainfall, evapotranspiration, and soil-water holding capacity. Simple soil-water balance models are available for doing such an analysis. However, due to the variability in rainfall

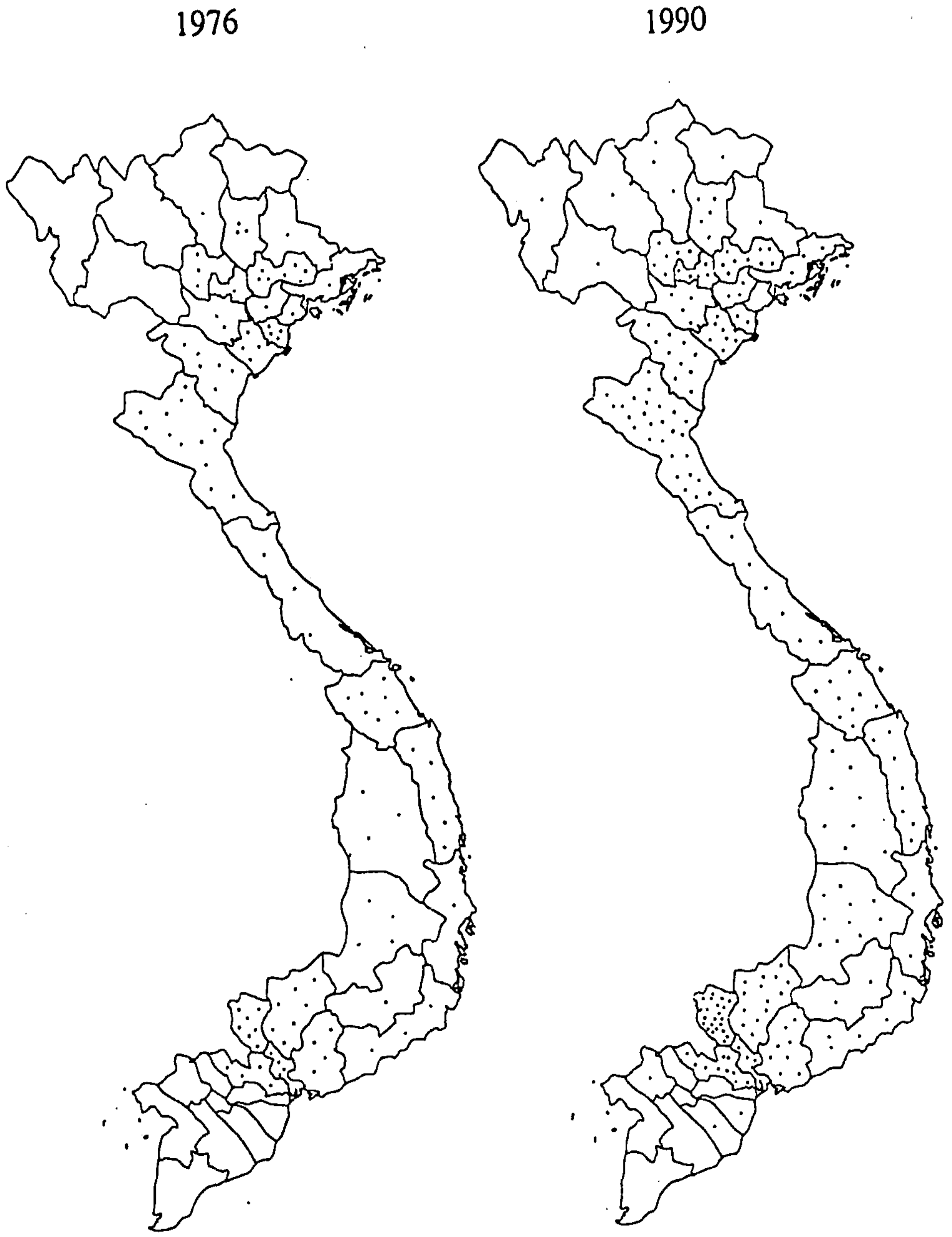


Figure 2. Area sown to groundnut in each province of Vietnam in 1976 and 1990. (Each dot represents 1000 ha.)

distribution between years, it would also be necessary to factor in probability values for available soil water at any particular time during the growing season. Probability analyses of the type used for rainfall data (Virmani et al. 1982) could be adapted to apply for available soil water. The challenge before us is to incorporate such probability information into EIS plots. These types of analyses will help us to establish possible drought limitations and to identify genotypes and crop management practices that will alleviate the problem.

As waterlogging is at least as important a constraint as drought towards the end of the growing season in northern Vietnam and during the rainy season in southern Vietnam, it is also desirable to delineate probable incidence and extent of water-

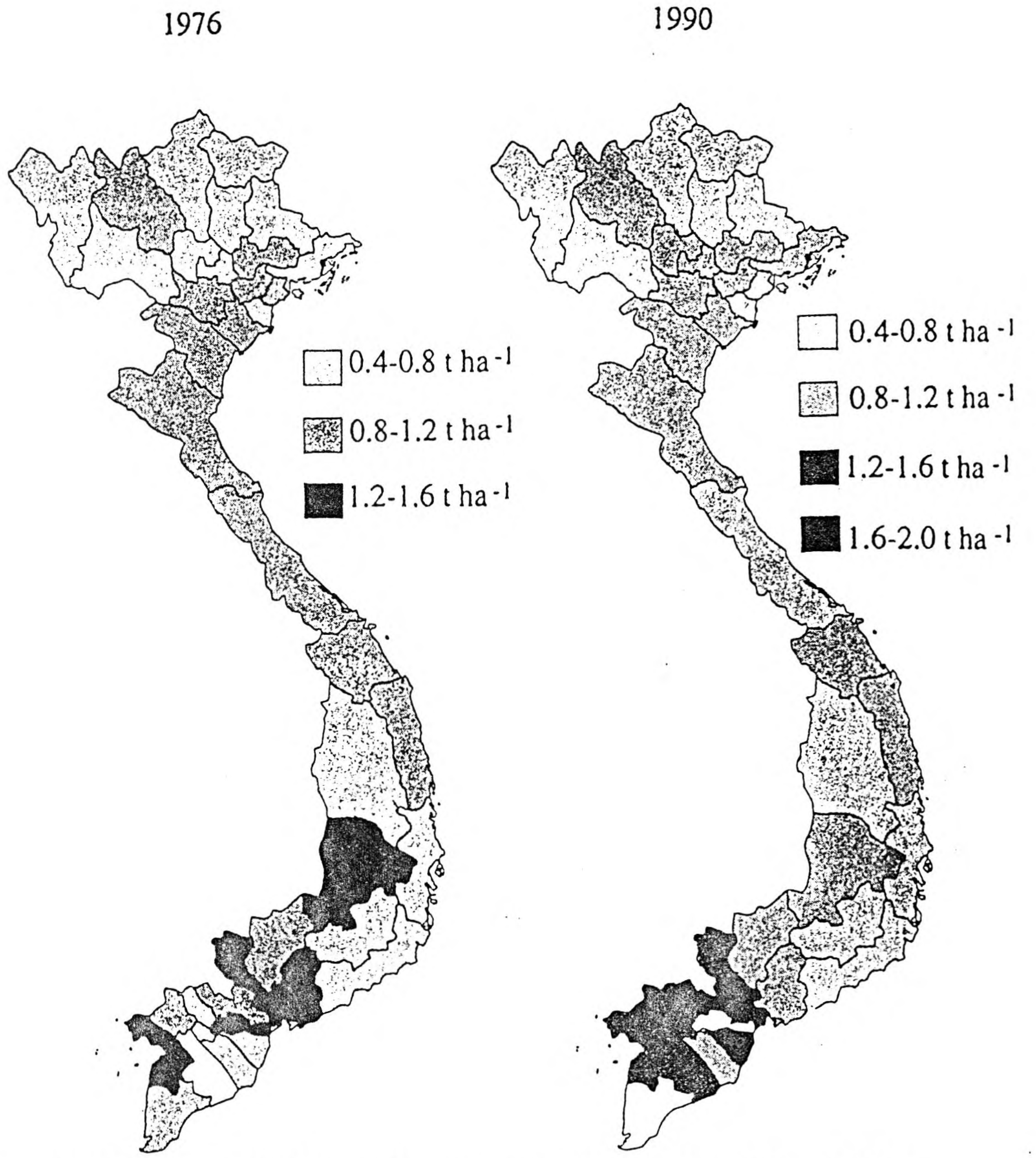


Figure 3. Groundnut yields in each province of Vietnam in 1976 and 1990.

logging damage. This may be done by calculating probability of incidence of rainfall on a fully charged soil profile.

We will also plot critical temperature isotherms that limit growth and yield of groundnut. Probability considerations will also apply to critical temperature plots, as discussed for available soil water. This information will guide us in genetic improvement of high or low temperature tolerance. There are also management options to overcome adverse temperature effects. For example, for low temperature stress at the establishment of the winter-spring crop in northern Vietnam, sowing of sprouted seed or use of polythene mulches covering the seed bed are available options.

We are also gathering information on pest and disease constraints to groundnut in Vietnam, which will be integrated into the EIS. We will examine how biotic constraints relate to various soil and climatic factors, by overlaying such databases, so as to gain insight into possible causal factors and control options. However, survey data for biotic stresses are generally incomplete, for any crop in any country. This is further complicated by seasonal changes in the pattern of pest and disease incidence. While we do not expect to be able to plot out biotic stresses in a comprehensive manner, we would recommend a more systematic method to record biotic stress data in a format compatible with EIS. This would require a uniform rating system to estimate the damage intensity or, preferably, extent of yield loss due to a particular biotic constraint.

Prospects for EIS in the Research and Development Process

EIS is proving to be a valuable tool in the research prioritization process, which is an improvement on the usual empirical way of deciding research priorities. Using EIS format to present research proposals for administrative/donor support is also seen as an advantage. EIS can be used to identify areas with potential for increased production of a crop, either by increases in yield or area under cultivation. It would thus guide us to site on-farm research trials for adapting improved technology.

EIS not only effectively displays current knowledge on crop constraints but also highlights gaps in that knowledge. It indicates where to direct surveys to obtain missing information. EIS provides both an incentive and a means (e.g., through standardized data entry format) for more comprehensive and regular surveys. This is a particularly important consideration for identifying and rating biotic constraints, about which there is usually limited information, especially regarding the distribution and fluctuation in incidence and severity over time.

EIS helps in better documentation, and attractive display of impact of research and development efforts. It can also display scenarios based on 'what if' questions. It facilitates integration of the continuum: basic/applied/adaptive research—extension—adoption—impact. It thus allows on-farm research to be placed in perspective and provides a feedback mechanism among components of the continuum.

EIS technology should be adopted as soon as possible by national agricultural research systems (NARS) for their use as a planning tool for crop and agricultural systems improvement on a national scale. International agricultural research centers (IARC) have a role to play in facilitating adoption of EIS by NARS, by helping to identify financial support to establish EIS and by providing training in the technology. IARCs can also assist by ensuring linkage to existing digitized databases, to help design standardized database assembly systems, and to promote compatibility of databases. The involvement of NARS is basic for obtaining the necessary data for EIS, and NARS should take maximum advantage of using the resultant databases.

In summary, EIS should facilitate future:

- research efficiency,
- development of research domains, and
- development of application domains (where best to apply established technologies).

References

Virmani, S.M., Sivakumar, M.V.K., and Reddy, S.J. 1982. Rainfall probability estimates for selected locations of semi-arid India. Research Bulletin no. 1 (2nd ed.). Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Virmani, S.M., Faris, D.G., and Johansen, C. (eds.) 1991. Agroclimatology of Asian grain legumes (chickpea, pigeonpea, and groundnut). Research Bulletin no. 14. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

National Digitization Project

National Science Foundation

Institute : Department of Agriculture

1. Place of Scanning : Department of Agriculture, Peradeniya
2. Date Scanned : 2018/1/29
3. Name of Digitizing Company : Sanje (Private) Ltd, No 435/16, Kottawa Rd, Hokandara North, Arangala, Hokandara
4. Scanning Officer

Name : G.E.D. Dilshan

Signature : ....

Certification of Scanning

I hereby certify that the scanning of this document was carried out under my supervision, according to the norms and standards of digital scanning accurately, also keeping with the originality of the original document to be accepted in a court of law.

Certifying Officer

Designation : Chief Librarian

Name : Saumya Upamalika

Signature : ....

Date : 2018/1/29

"This document/publication was digitized under National Digitization Project of the National Science Foundation, Sri Lanka"