A CROPPING SYSTEMS TECHNOLOGY DEVELOPMENT PROCESS: THE NERAD EXPERIENCE 1/

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INTRODUCTION

The major goal of the Northeast Rainfed Agricultural Development (NERAD) Project is to develop a replicable farming systems approach for rainfed agricultural development in Northeast Thailand. 'Farming Systems' is currently a popular phrase in agricultural development but often means very different things to different people. One aspect, however, that most farming systems practitioners are in agreement on is the importance of on-farm research and extension trials.

NERAD has been conducting on-farm trials for 3 years. In the early years, government scientists implementing the trials soon discovered that not only is the production environment on small farms very different from that which they were used to on experiment stations but so also is the research environment. Many problems were encountered as experiment station procedures were applied to on-farm trials and found to be lacking. Even methodologies developed for on-farm trials by the international institutes, most notably IRRI, were often inappropriate for the government program of NERAD because of differences in expertise, equipment, staffing and field assistance. The initial and understandable response of the Ministry of Agriculture officials responsible for conducting the trials was to throw out all scientific rigour entirely. In some cases, the only data collected were yields, often measured in inappropriate units; cultural practice recommendations were often arbitrarily arrived at, no treatments or check plots were selected or monitored, participating farmers and trial plots were often chosen solely on the grounds of convenience, etc., etc. In most instances very little information was obtained from the trials which added to the researcher's understanding of the major problems or led to ways of helping to solve the problems already identified.

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In addition, the traditional links between research and extension did not exist at the farm level and the early response was for researchers and extensionists to conduct their activities in virtual isolation from each other. At one time 3 separate sets of trials were being conducted within NERAD by DOA, DOAE and NEROA. In short, NERAD cropping systems development was multi-disciplinary and multi-departmental but not inter-disciplinary nor inter-departmental.

Finally, an overall framework for cropping systems development within NERAD, utilizing all available resources within the Ministry of Agriculture, had not been established. Although on-farm trials were being implemented, their relevance to farmer problems was in some cases questionable; problems encountered in farmers' fields were not being communicated back to the research stations or technical divisions of DOA and there was no clear understanding of how promising technologies would be further developed and extended to farmers in the future.

In conclusion, 3 major problems were facing NERAD:

- Lack of an overall process for developing cropping system technologies.

- Lack of an on-farm trial methodologies and appropriate experimental procedures.

- Poor links among researchers, extensionists and farmers.

The following sections describe the current status within NERAD in attempting to overcome these problems.

PROCESS DEVELOPMENT

Figure 1. presents and defines the various phases of technology development and illustrates their relationship to basic research and experiment station trials as currently conceptualized within NERAD. There are two important characteristics of the process. First, it is a TWO WAY FLOW technologies are tested, screened and improved at each stage of the process but information gained at each phase also 'feeds back' to previous phases. Secondly, the process is ITERATIVE and does not end with farmer adoption of the improved technology. As new technologies are adopted by farmers on a large scale, then new constraints will emerge as the farming system is adjusted to incorporate the improved technology. This will require identification of new problems and the process will begin over again.

The process has 3 major objectives. First TESTING of improved technologies under the real conditions of the farmers for whom they are being developed. Second, LEARNING about farmers' problems and constraints and the performance of the improved technologies in order to be able to modify them to improve their performance in the future. Thirdly, COMMUNICATING shortcomings of the new technologies and other farmer problems requiring further research to the experiment stations and other appropriate research agencies.

METHODOLOGY DEVELOPMENT

Methodology development within NERAD can best be described in two parts. The first concerns the development of experimental design, trial lay-out and data collection procedures for on-farm and multi-location trials that can be practically implemented with available resources while at the same time following sound scientific principles (See Table 1.). Data collection has now been standardized across all sites and efforts are now concentrating on computerizing the entire data storage, analysis and reporting system. A 'super-imposed treatment' methodology has been implemented in the on-farm-trials with treatments being chosen according to the most important problem identified by farmers in previous years' trials. Check or control plots are included in the trial design but have very different objectives in the on-farm and multi-location phases. In the former, check plots are designed to add to the researchers's understanding of the performance of a new technology. For example, in a trial comparing 2 fertilizer rates for kenaf last year a check plot with no fertilizer was included in order to obtain a response curve for fertilizer under on-farm conditions. The major objective of the check plot in the multi-location phase, however, is farmer-demonstration and check plots are chosen to demonstrate to farmers the major benefits of the new technology being multi-location tested. For example, in the Northeast with it's poorly-buffered, sandy soils of low inherent fertility, rice-based, cropping-pattern trials should have a fallow-rice check plot to demonstrate to farmers the often considerable residual effect of a first crop on the following rice crop (See Figure 2).

The second area of methodology development concerns the application of various analytical tools to a national FSR program such as NERAD. As Table 2 illustrates, Thailand is rich in such FSR methodologies but unfortunately they are often viewed as mutually exclusive 'APPROACHES' rather than being seen as available 'TOOLS' appropriate at different stages in the technology development process. With assistance and cooperation from Khon Kaen and Chiang Mai Universities, the Office of Agricultural Economics and others, NERAD has used these methodologies at various times over the past 4 years. Figure 3 shows, according to NERAD's experience, how the different methodologies are appropriate at different stages in the technology development process.

Agroecosystems analysis (A.A.) is a very useful macro-level analysis tool and has been shown to be extremely helpful for site selection. It was used within NERAD during the site description phase to organise information, identify problems and set research priorities. Although not used in NERAD some francophone systems-analysis (FFSR) procedures are very similar and are also considered appropriate at this stage. Indeed the system dynamics emphasized by the FFSR approach, is a very powerful complement to A.A. during site description.

NERAD's R.R.A. experience which is described in more detail by Alton (1986), was extremely valuable in refining, in conjunction with the farmers, some of the general hypotheses produced by A.A. into researchable questions that could be tested by on farm trials. It was also during the early RRA's that the first seeds of interdisciplinary cooperation within NERAD were sown. Although not articulated as such, testing of indigenous technologies is being conducted within NERAD and includes 'Surin' post-rice peanut in Roi Et and 'Roi-Et' pre-rice kenaf in Chaiyaphum. Due to differences in research resources and time constraints, the in-depth level of research necessary for the successdul implementation of this approach has not been possible within NERAD. What is possible within a program such as NERAD, however, is the implementation of the results of such an approach following clearly defined guidelines similar to those being developed for post-rice peanuts by the KKU team.

Methodologies for analysing and screening the many technologies tested at each phase of the technology development process are critical components of a sucessful process. NERAD's experience would indicate the analysis procedures from the 'new-technology - based' CSR approach are more appropriate during the 'research-managed' on farm trial phase while those from the £farmer-problem-based' FSR approach are more appropriate for the £farmer-managed' multi-location phase. A modified triage technique using the results of these CSR and FSR analyses is also being used in NERAD to screen technologies and set future research and extension priorities according to the biological, economic and social performance of thetrial technologies.

The use of linnear programming models based on farm record keeping data to assess the appropriateness of the new cropping system technologies on the entire farm system is being used by NERAD as an analysis tool and is described in detail by Promnoe (1986). Finally, farmers are included as the most important (and the most discerning) screening methodology in the entire process. Only a very small proportion of all technologies developed will pass the farmers' screening procedures and be adopted. However, if research and extension workers can learn more about farmers' screening criteria and incorporate these at the technology design phase then the effectiveness of the entire technology development process will be increased significantly.

INTERDISCIPLINARY DEVELOPMENT

NERAD has adopted a work group approach in order to improve interdepartmental cooperation and to enhance the integration of diverse farming system activities in a holistic manner (See Figure 4). NERAD's cropping systems trials, whether they be on-station, on-farm, multi-location or whatever are now planned, implemented, analysed and screened for each site by a Changwat-level working-group composed of representatives of the following Departments: DOA, DOAE, OAE, CPD, DLD and NEROA. Although functioning as a team, distinct departmental leadership and support roles have been defined for each phase of the technology development process and these are detailed in Table 3. Results of each phase are presented, reviewed and analysed and plans for the following year are formulated in an interdepartmental, annual cropping-systems technical-workshop where staff from all levels of all departments at all sites meet to exchange results.

MULTI-LOCATION: THE KEY PHASE

The multi-location trial phase is singled out ther for a more detailed explanation of the multi location trial phase for two major reasons. First, it is considered one of the most critical stages in the entire technology development process. Secondly, it is a relatively new concept in Thailand and is being implemented by NERAD in a significantly different manner than elsewhere and with considerably different objectives from those described by Zandstra, et al. (1981).

It is during the multi-location phase that a trial technology makes the most rapid transition from a research hypothesis to a farmer practice. Figure 5 shows how multi-location is critical in a number of ways. The mix of research and extension are approximately equal and this phase therefore offers a real opportunity for integration between research and extension to be improved. In addition, the farmer is taking over from the researcher as manager and decision maker for the technology which is consequently likely to undergo rapid adaptation to meet the farmer's needs. Finally, the number of technologies tested is declining while the number of farmers applying these technologies is increasing significantly. Consequently, it is essential that the technologies being multi-location tested are able to demonstrate well-proven benefits.

Multi-location trials were designed and introduced within NERAD to meet a number of important objectives. The characteristics of the trials in this phase are therefore specifically tailored to these objectives while at the same time attempting to ensure compatability with the Thai MOAC system. The major objectives of multi-location trials are as follows:

1. <u>To Introduce Farmer-Managed Trials to Complement the Research-managed, On-farm-trials Phase.</u>

Although satisfactory agronomic and basic economic data were being generated by the on-farm-trials, there was very little information concerning the extent to which the trial technologies were compatible with the entire farm system or how they took into consideration the socio-economic constraints of the farmers. Multi-location trials were designed to overcome this shortfall. In these trials the farmer is expected to make most management decisions himself and supply all the labor and some of the input costs.

2. <u>To Improve Integration Between Research and Extension Personnel.</u>

By introducing a trial phase with approximately equal emphasis on both research and extension where DOA and DOAE officials both work closely with farmers in their fields, the benefits of close-knit research-farmer-extension teams can be demonstrated and channels established for improved information flow amongst farmers, extension and research.

3. <u>To Provide a Link Between DOA's On Farm Trials System and DOAE's Training and Visit System</u>

Although not yet conducted as such within NERAD, the multi-location trials could be incorporated into the T & V system. One possible scenario is as follows:

(i) DOA establish on-farm trial plots of a technology be appropriate for multi location in the Amphur.

(ii) DOA give technical training on that technology based on previous on-farm-trial results to DOAE through the T & V fortnightly training program.

(iii) Kaset Tambons establish multi-location trials and assist participating farmers with these as part of the fortnightly visit system.

(iv) Kaset Tambons also visit DOA's on-farm trial plot as part of the fortnightly visit schedule to receive from DOA researchers technology updates and solutions to problem as they occur which they can then pass on to multi-location farmers through their fortnightly visit system.

4. <u>To Improve the Effectiveness of the Extension Phase by Significantly Increasing the Number of Extension Trials</u>

As a general guideline, twice as many multi location as on farm trials are implemented per site. This compares to the previous situation where fewer than half as many demonstration plots as on farm trials were conducted. The consequent four-fold increase in extension trials thus achieved was made possible by manpower savings through increased farmer management and some budget savings through supplying only essential inputs to farmers.

5. <u>To Improve Data Collection and Utilization Procedures in the Extension Phase.</u>

Three types of data will be collected from multi location-trials. For the small increase in effort required to collect them, these data will greatly add to the useable information being generated by the trials. Baseline, farm-system data will be collected from all participating farmers so that an assessment of how the new technology interacts with the traditional farm system can be made. Farmer practice data will be collected to see how closely farmers followed recommendations. Analysis of these data will allow an assessment of the appropriateness of the technology for farmers and begin to identify socio-economic constraints associated with the technology. Finally supplemental data from other sources such as rainfall, soils analysis, market prices, etc. will be used in the analysis of results of the trials.

The following cropping system technologies will be multi-location tested by NERAD this year:

Chaiyaphum:	1.	Direct sown rice
	2.	Mungbean before rice
	3.	Cuban kenaf before rice
Sri Saket:	1.	Yardlongbean before rice
	2.	Green manure for rice
Roi Et:	1.	New kenaf variety
	2.	White sesame before rice
Nakorn Phanom:	1.	Jute-watermelon
	2.	Sesame-watermelon
	3.	Peanut-watermelon

For each technology being tested, technical bulletins were prepared by the relevant changwat Cropping Systems Working Groups. These describe the technology and its objectives, summarize the results of the trials to date, define the agroecological and economic conditions for which it is appropriate and list recommended practices for its successful implementation. These bulletins are then used as guidelines for implementing the multi location trials. Two examples are summarized in Tables 4 and 5.

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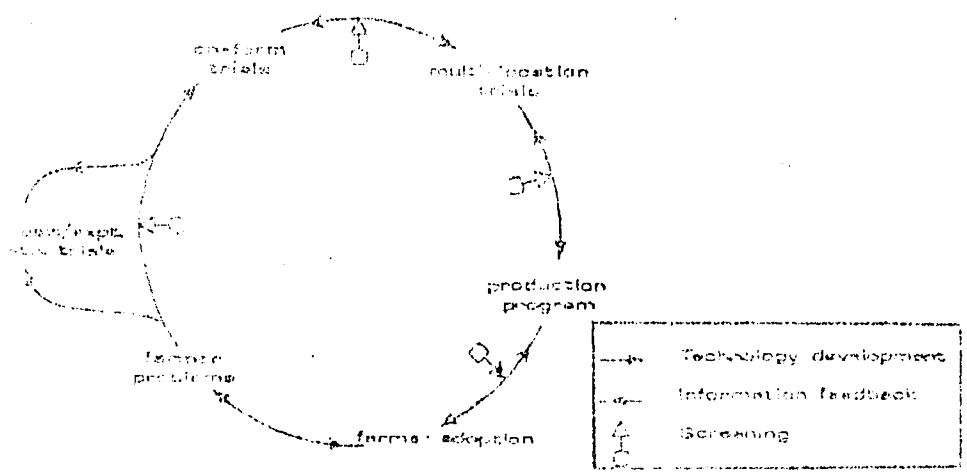
Figure 1. [illegible]'s Cropping Systems Technology Development Process



I. FARMER PROBLEMS: Problems that are significantly reducing the productivity or profitability of crop production systems or constraints that are critically limiting development opportunities which are experienced by a significant [illegible] of the farmers in the target area.

II. BASIC OR [illegible]: Available technologies (crops, varieties, etc.) or [illegible] designed to produce technologies applicable for local farmer conditions.

III. ON-FARM TRIALS: A test of [illegible] improved technology in a farmer's field conducted jointly by research, extension and the farmer under the leadership of the [illegible]. The farmer [illegible] and [illegible] the day to day [illegible] control of the [illegible] all [illegible].

IV. MULTI-LOCATION TRIALS: [illegible] testing of [illegible] farm trials [illegible] farmers' fields [illegible] the leadership of [illegible] supplies and [illegible] free but the farmer [illegible] management [illegible] the input costs.

V. PRODUCTION PROGRAM: Farmers [illegible] existing [illegible] to make wide-scale adoption [illegible] technology [illegible] the credit [illegible] quality of [illegible] markets, etc.

VI. FARMER ADOPTION: [illegible]

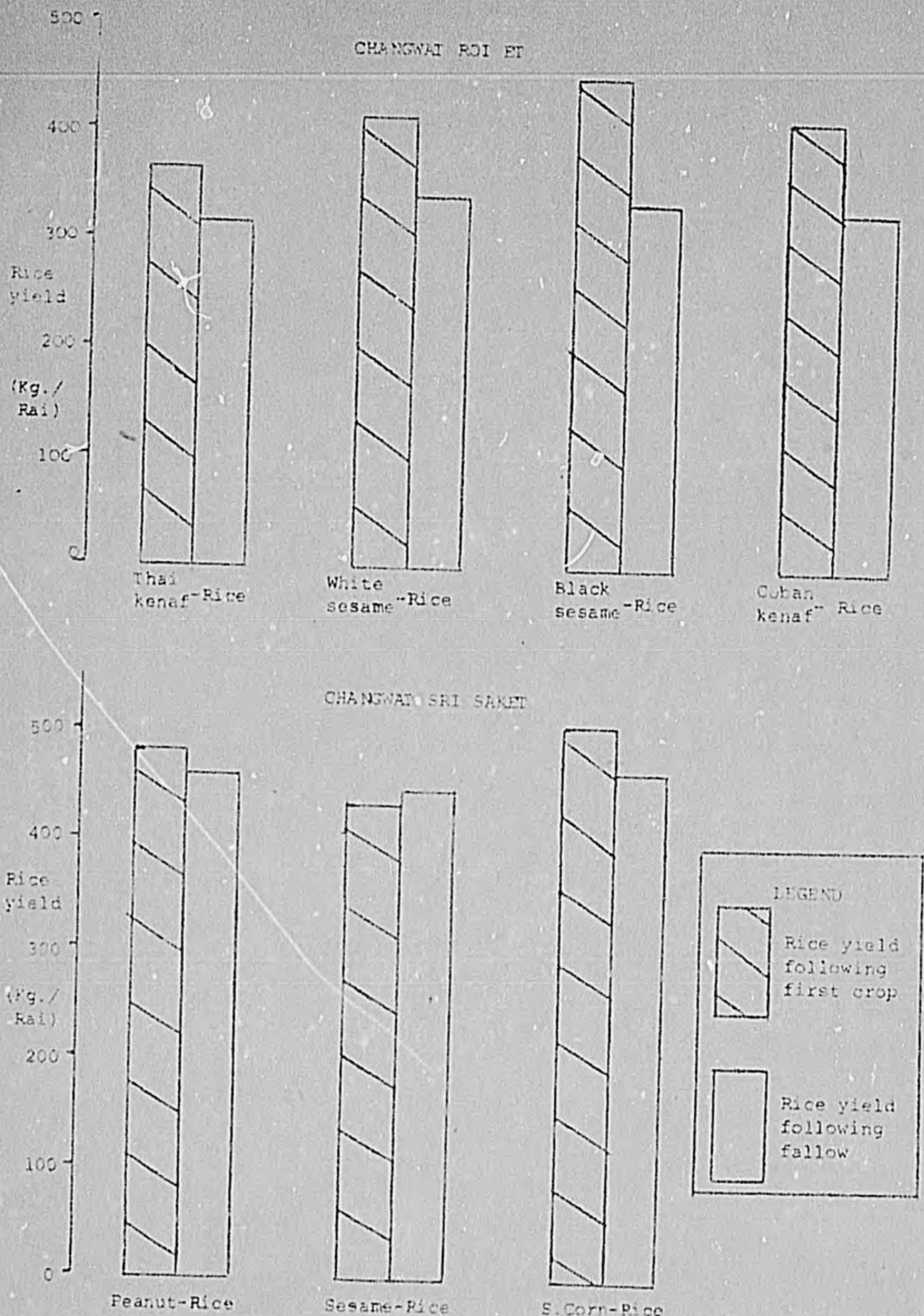


Figure 2. Showing the residual effect of a first crop on the following rice crop, NERAD rice-based cropping system trials, 1985.

Figure 3. Optimum utilization of available systems methodologies within NERAD.

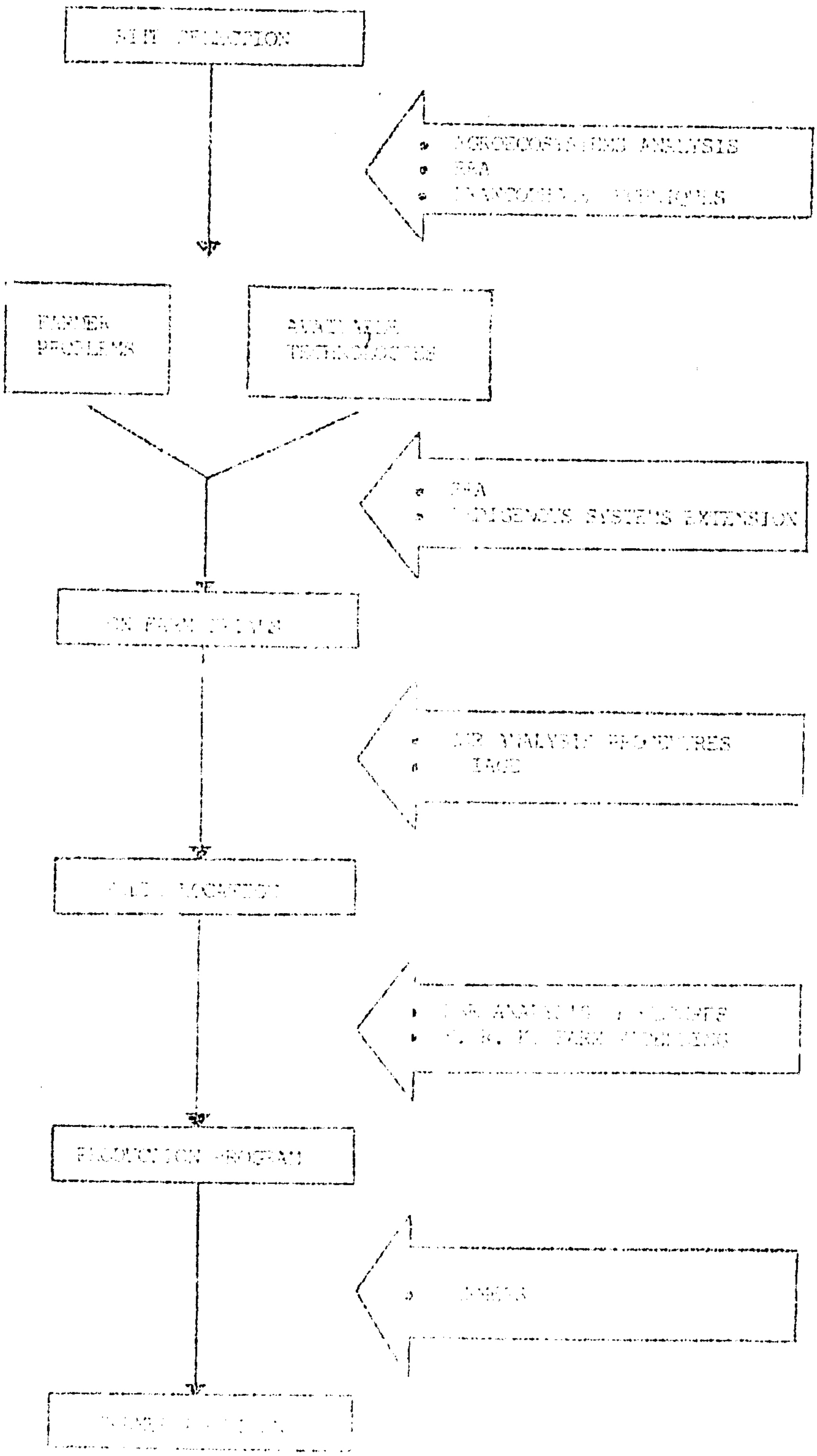


Figure 4. Interdisciplinary integration of farming systems activities within NERAD

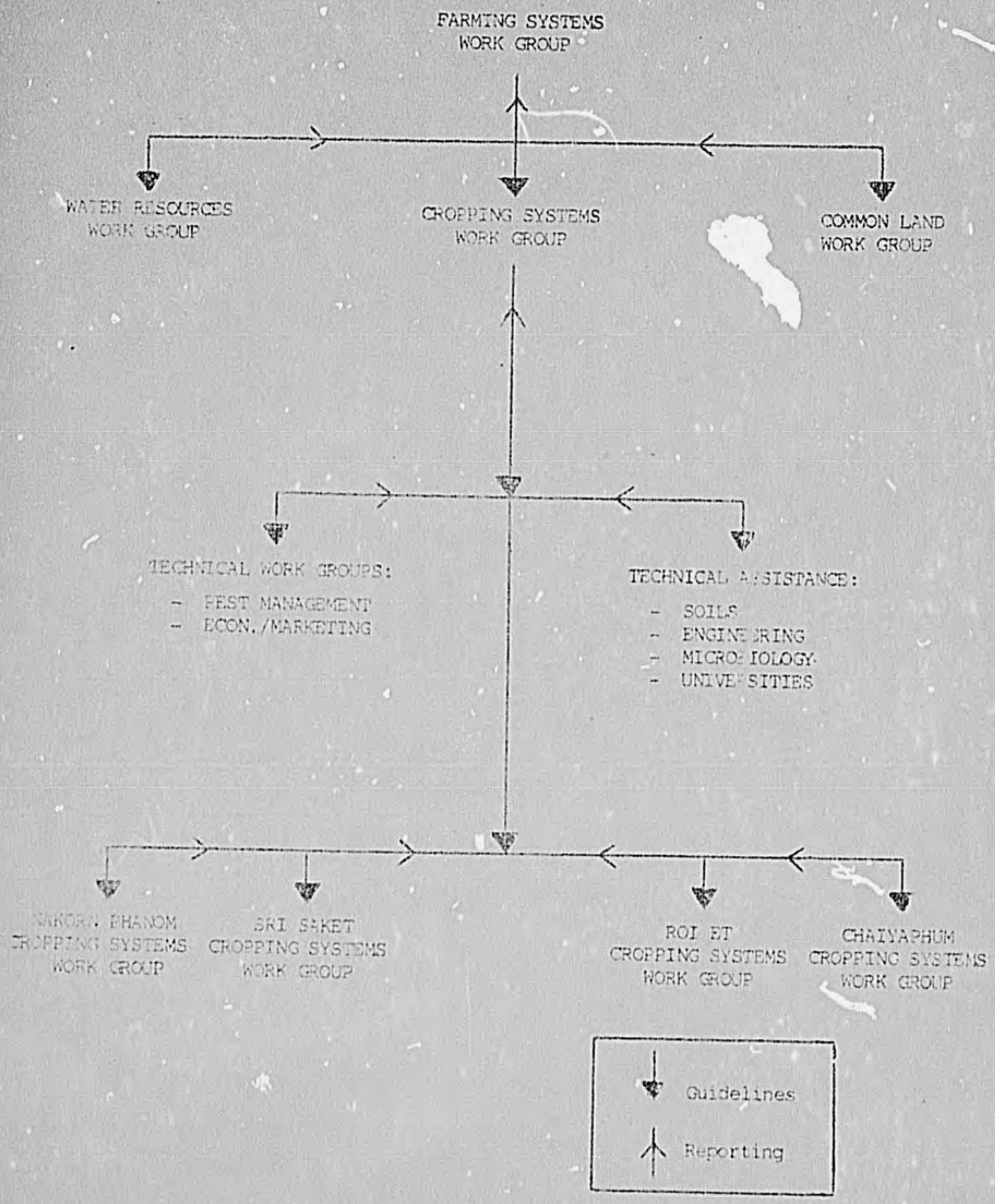


Figure 5. Changes in key parameters during the technology development process.

[illegible] Phase of [illegible] Cropping Systems Development Process

	BASIC RESEARCH	RES. STN. TRIALS	ON-FARM TRIALS	MULTI-LOCATION TRIALS	PRODUCTION PROGRAMS
OBJECTIVES	Develop new agricultural production technologies	Initial screening and refinement of new technologies	Matching new technologies with farmer problems under real farm conditions	Farmer testing and initial extension of promising technologies	Technical and infrastructure support to enable wide-spread adoption
EXAMPLES	Breeding/lab work/ physiological studies	Varietal screening/ planting-date studies	Cropping pattern testing with superimposed treatments for critical factors	Testing of promising technologies	Input and market support
NUMBER OF TECHNOLOGIES TESTED	Many	Many	Approx. 5	Approx. 2	1
TRIAL DESIGN CHARACTERISTICS	- V. high degree of control - Sophisticated treatments	- High control - Complex treatments - Standard replicated designs	- Researcher managed - Adequate control - Simple superimposed treatments - Replication across farms - Inputs given free to farmers	- Farmer managed - Minimal control - Zero or 1 simple treatment + check - Farmer supplies some inputs - Replication across farms	- Sample composed of early adopters of technology
TYPE OF DATA GENERATED	Highly detailed in one discipline	Detailed agronomic data	Basic agronomic and economic data	Simplified agronomic and economic data + detailed farmer-practice data	Macro-level data + data on farmer problems
TYPE OF ANALYSIS	Sophisticated statistical analysis	Standard statistical analysis	Simplified/modified standard statistical procedures (c.f. FSSP modules)	Simple hypothesis-generating type analysis for feedback to on-farm trials	Analysis of macro-level problems
NUMBER OF TRIAL PLOTS	-	1/Expt. Sta.	4-10/site	10-20/site	50/site

Table 2. System methodologies currently being implemented in Thailand.

METHODOLOGY	DESCRIPTION	REFERENCES
FARMING SYSTEMS RESEARCH	Collaborative development of agricultural technologies focussing at the farm level by a joint researcher, farmer, extension team	Hildebrand et al., 1985; Caldwell, 1983; Hildebrand 1983.
CROPPING SYSTEMS RESEARCH	Increasing crop production on a given piece of land by increasing the yield of a crop or by growing an extra crop. This approach also emphasises on-farm trials.	Zandstra et al., 1981; Hoque, 1984; IRRI, 1977.
AGROECOSYSTEMS ANALYSIS	An interdisciplinary analysis procedure for setting research priorities for any complex agroecosystem.	Gypmantasiri et al., 1980; KEPAS, 1984; KKU, 1982 a & b; Limpinuntana, et al., 1982.
FRANCOPHONE FSR	Interdisciplinary analysis procedure emphasizing the dynamic nature of agricultural systems and associated research methodologies which emphasize natural phenomena observed in farmers' fields as experimental treatments.	Trebuil, 1982; Trebuil et al., 1983; Crozat, 1985.
RAPID RURAL APPRAISAL	Semi-structured interviewing technique used to obtain an inter-disciplinary needs assessment of farmer problems or development opportunities.	Carruthers et al., 1981; Chambers, 1980; Anon., 1985.
INDIGENOUS TECHNOLOGY EXTENSION	A methodology for the technical analysis of indigenous farmer technologies and their extension to other areas of similar agro-ecological conditions.	Anon., 1985; Jintawet et al., 1985; Jintawet, 1985.
F.R.K. AND FARM SYSTEM MODELLING	The use of computer models (simulation and optimization) based on farm record keeping data to analyze new technologies at the farm level	Promnee, B. 1986; Jayasuriya et al., 1984.
TRIAGE	An inter-disciplinary analysis tool for assessing the biological, economic and social performance of trial technologies and for setting future development priorities.	Ragland et al., 1985; Craig et al., 1986.

Table 3. Departmental and Disciplinary Roles for Each Phase of NERAD's Cropping Systems Development Process.

	BASIC RESEARCH	RES. STN. TRIALS	ON-FARM TRIALS	MULTI-LOCATION TRIALS	PRODUCTION PROGRAMS
LEADERSHIP IN IMPLEMENTATION	DOA Technical Divisions	DOA Institutes	DOA (FSRI)/DOAE	DOAE/DOA (FSRI)	DOAE/CPD
NATURE OF INTERDEPARTMENTAL SUPPORT (KEY AGENCIES)	1. Communicating farmer problems to set research priorities (DOAE/DOA INSTITUTES)	1. Feedback of farmer problems (DOAE/FSRI) 2. Technical support (DOA TECH. DIVISIONS)	1. Trial planning (ALL DEPTS.) 2. Feedback of farmer problems (DOAE) 3. Technical support (DOA INSTITUTES DOA TECH. DIVISIONS) 4. Economic analysis (OAE) 5. Market analysis (CPD/OAE)	1. Preparation of technical bulletins for each technology (FSRI) 2. Technical support (DOA) 3. Economic/social analysis (OAE)	1. Preparation of extension pamphlets (DOAE/DOA) 2. Farmer training (DOAE) 3. Demonstrations (DOAE) 4. Economic & Market evaluation (OAE/CPD)
RESEARCH:EXTENSION (ratio)	100:0	95:5	75:25	30:70	10:90
MANAGEMENT-RESEARCHER: FARMER (ratio)	100:0	100:0	70:30	20:80	5:95

Table 4. Technical Bulletin: Direct Sown Rice

OBJECTIVES:

1. Ensure a rice crop every year on land that does not always receive sufficient rainfall for transplanting.
2. Reduce the risk associated with transplanted rice in conditions of erratic rainfall.
3. Increase rice yields when transplanting is delayed due to late rain.
4. Reduce labor requirements and remove labor bottle-necks at transplanting time.

RESULTS SUMMARY:

Direct Sown Rice Yields (kg/rai), 1985

	Amphur Chatturat		Amphur Phukhieo	
	Direct sown	T.P. check	Direct sown	T.P. check
	416	[illegible]*	415	268
	330	0*	454	484
	436	[illegible]	137	178
	542	476	[illegible]	247*
	563	578	117	0*
Mean:	507	339	303	235

* Insufficient water for transplanting control plot.

Economic Analysis

Current cost of seeder	(Baht)	2500
Real annual cost (assuming 12% interest and machine life of 10 years	(Baht/year)	450
Cost per rai (assuming 8 rai/day and a 2 week planting period)	(Baht/rai)	4
Other additional costs of direct sowing (extra seeds, insecticide, etc.)	(Baht/rai)	52
Total cost per rai	(Baht/rai)	56
Increase in rice yields	(kg/rai)	118
Cost per kg of increased yield	(Baht/kg)	0.47

RECOMMENDED PRACTICES:

- Plow 2-3 times, harrow, remove weeds and plant RD15 or RD6 immediately using 2 row seeder set at 25 x 25 cm spacing (7-8 kg/rai).
- Plant June 15-30.
- Leave rice bunds open for free drainage until 15-20 cm stage and then close bunds to maintain standing water if rainfall is assured.
- Apply 16-16-8 (20-30 kg/rai) at 5-10 cm stage and top-dress with 20-0-0 (5-10 kg/rai) at panicle initiation. Incorporate carbofuran granules (4 kg/rai) with 1st fertilizer application.
- Further pest control and cultural practice recommendations same as for transplanted rice.

APPROPRIATE CONDITIONS FOR EXTENSION AND LIMITATIONS OF THE TECHNOLOGY.

- Any paddy land where rainfall patterns are unreliable but heavy clay soils should be avoided.
- Glutinous or non glutinous rice growing areas.
- Especially appropriate in conditions of labor shortage at transplanting time.
- Avoid planting in periods of high rainfall probability.
- Thorough land preparation is essential for successful direct sowing.
- Avoid paddies with especially high weed populations.
- Insect, disease and vertebrate pest problems may be more severe with direct sowing (especially, thrips, mealy-bugs blast and rats).

Table 5. Technical Bulletin: Green Manuring

OBJECTIVES:	1. Increase rice yields. 2. Reverse the trend of declining soil fertility in the paddy land. 3. Reduce the cost and associated risk involved with the use of chemical fertilizer. 4. Increase O.M. levels and improve the water-holding capacity of paddy soils
RESULTS SUMMARY:	(see table below)

Farmer	Rice yield following cowpea green manure (kg/Rai)		Rice yield after fallow -CHECK- (kg/Rai)		Rice Yield (farmer-practices) after fallow -FARMERS CHECK- (kg/Rai)	
	TAE	TAKET	TAE	TAKET	TAE	TAKET
1	526	566	531	470	419	438
2	425	864	411	522	439	382
3	688	522	619	492	720	347
4	496	439	459	368	418	537
5	567	486	533	457	460	404
6	520		560		431	
7	486		379		378	
8	568		401		385	
9	516		523		433	
10	471		569		466	
Mean	526	575	499	464	455	421

** Differences significant at 99 per cent probability

RECOMMENDED PRACTICES:	- Plough, harrow and broadcast cowpea (5 kg/rai) from April 15 - May 15. - Apply lime during land preparation (100 kg/rai) if pH is less than 5.0 (moist soil). - Spray dimethoate during seedling stage for beanfly control. - Plow-in cowpea at 45-50 days post-planting. - Maintain standing water in field after plowing-in until land preparation for rice.
APPROPRIATE CONDITIONS FOR EXTENSION AND LIMITATIONS OF THE TECHNOLOGY:	- Any paddy land where prolonged water-logging can be avoided during cowpea growth. - Soil pH [illegible] 5.0 at planting time. - Land where standing water can be maintained for 1 month pre transplanting is advantageous. - Especially appropriate and more readily acceptable to farmers in areas with a history of low fertility and low O.M.