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PROBLEMS AND OPPORTUNITIES FOR FARMING SYSTEMS BASED ANNUAL CROP DEVELOPMENT IN NORTHEAST THAILAND.

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PREFACE

This document has been printed and distributed by the Northeast Rainfed Agricultural Development Information and Coordination System (NERADICS) of the NERAD Project. The purpose of NERADICS is to establish, at the Northeast Regional Office of Agriculture, a system to manage Project-generated data and information in order to support the testing, transfer and dissemination of technologies, methodologies and approaches appropriate for integrated agricultural research and development in Northeast Thailand.

Technical working papers are produced with the objective of communicating project-generated information to the relevant research and development agencies in order to receive comments and feed-back and to help to ensure that the lessons learned within NERAD are made available to all interested individuals and organizations.

Working papers are produced on a number of topics and are grouped into three series according to their subject matter:

Technology Documentation Series

Documentation of technologies considered appropriate for rainfed agricultural development in Northeast Thailand

Methodology Description Series

Descriptions and methods of use of proven methodologies and techniques for the planning, analysis and evaluation of research and extension activities for rainfed agriculture.

Problem Definition Series

Situation papers on the problems, constraints and opportunities currently facing rainfed agriculture and farm families in Northeast Thailand.

All papers in these series are listed in the Appendix of this report and are available on request from the Project Director. The papers are updated at appropriate intervals and NERAD invites comments and discussion from readers on any topic covered in the reports.

PROBLEMS AND OPPORTUNITIES FOR FARMING SYSTEM BASED ANNUAL-CROP DEVELOPMENT IN NORTHEAST THAILAND

INTRODUCTION

This paper deals with the symbiotic relationships between annual crops and other components of the farm system. Symbiosis is defined by ecologists as "the association of dissimilar organisms to their mutual advantage". To the layman it means a way of getting something for nothing but for the purposes here it is best described as "any beneficial interaction between annual crops and other components of the farm system that improve the performance of the system as a whole". Symbiosis relies on system interactions, in this case interactions between annual crops and other components of the rainfed farm agro-ecosystem in Northeast Thailand.

The typical farm agroecosystem of the Northeast is a small, predominantly crop-based, mixed-farm. Off-farm employment is often a very important component of the system and will sometimes generate more income than the farm itself. For on-farm activities, 80 per cent of agricultural income comes from cropping activities with the remainder accruing from the sale of livestock, fish, the production of silk and charcoal and the sale of forest products, etc. The major annual crops are rice for subsistence and sale in the paddy land and cassava or kenaf on the upland. Ninety-five percent of the region has no irrigation and the crop production environment is characterized by extremely poor soils and rainfall with extremely high annual variability. Annual crop production strategies and other components of the farm system have co-evolved in response to local agro-ecological conditions and farm-family requirements. Staggered planting dates, cultural practices and the crops chosen are the most common farmer strategies for dealing with this unproductive and highly variable environment (Craig and Pisone, 1985).

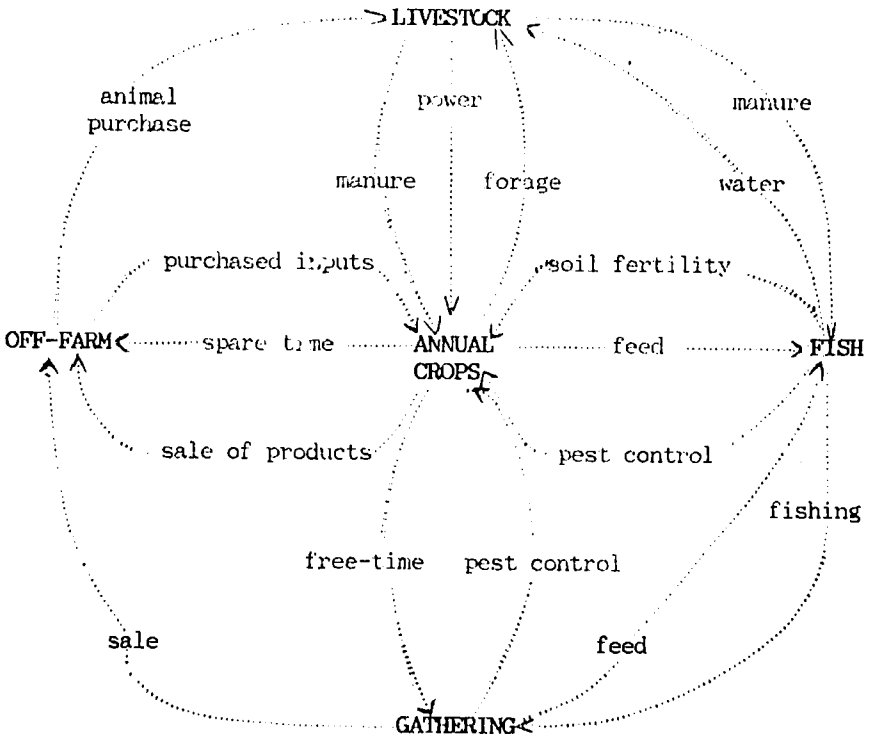
As shown in Table 1, both the major annual crops are ideally suited components of the agroecosystem. In rice, for instance, photo-sensitive varieties are used enabling planting dates to be adjusted depending on if and when there is sufficient water for transplanting, the fields are bunded to maintain standing water to enhance nutrient availability, farmers keep a number of years rice supply in their barns to carry them over years of low production and they use minimal purchased inputs to reduce risk in drought or flood years when they may lose the entire crop. Cassava, the other main annual crop, also requires minimal cultural attention and cash inputs, it is tolerant to drought, thrives on infertile soils and harvesting can be adjusted to suit cash needs or family labor availability.

Table 1. Suitability of the two major annual crops to the crop production environment in Northeast Thailand.

PADDY RICE	PREVAILING CONDITION	CASSAVA
Capable of growing under reduced, water-logged conditions	POOR SOILS	Efficient extractor of nutrients in infertile soils
Photosensitive varieties can be kept in the seed-bed until sufficient rainfall for transplanting	VARIABLE RAINFALL	Tolerant to drought by virtue of its ability to regulate leaf area index according to water availability
Can be grown under low input levels	LACK OF CAPITAL	Low or zero inputs required
Very little labor required between planting and harvesting	OFF-FARM ACTIVITY IMPORTANT	Two planting times and flexible harvest according to family labor availability
Produces straw for livestock and fish, crabs, etc. are collected from the paddy	MIXED FARM IMPORTANT	Labor peaks don't conflict with other farm enterprises and harvest can be adjusted to family cash requirements

In addition to being ideally suited components of the agroecosystem, these crops are also intimately linked with other farm system enterprises (Figure 1) and thus improvements to annual crops can have a variety of effects that may be either beneficial or detrimental to other components of the farm system. It is the contention of this paper that the interactions between annual crops and other components in the farm system and the way the farmer manipulates them in line with his objectives has to be understood if undesirable effects are to be avoided and if beneficial or 'symbiotic' effects are to be capitalized upon.

Figure 1. Major interactions of annual crops with other components of the farm system.



FARMER STRATEGIES FOR SOLVING ANNUAL CROP PROBLEMS

The study and analysis of traditional farming systems is needed to identify the farmer strategies being followed in the management of important farm system interactions. Many tools for identifying farmer strategies have been used and refined by NERAD including agro-ecosystems analysis, rapid rural appraisal and other techniques that are already quite widely used in Thailand (Gypmantasiri, et al., 1980; Trebuil, 1982; Anonymous, 1982; Jintawet, et al., 1985; Conway, 1986; Alton et al., 1987).

Many examples of farmer practices that are in harmony with important farm system interactions exist for Northeast Thailand. Indeed, the intimate relationship of the farmer, his farm and the natural environment is probably the main sustaining force in the agroecosystem.

Low Soil Fertility

NERAD has identified a number of strategies used by farmers to manipulate crop/livestock interactions in order to improve soil fertility (Craig, 1985). Farmers in Amphur Muang, Roi Et, for example, grow water-melon in the paddy with the objective of maintaining the yield of the following rice crop through the cattle manure applied to and paid for by the water-melon. Other farmers carefully air dry their animal manure, which volatilizes off much of the N, but is necessary to avoid the soil pH reduction associated with the application of fresh manure. The dried manure is then generally applied intensively to a few fields each year in order to support intensive cropping systems for that year in those fields. Manure application is rotated around the whole farm over a number of years to spread the effect.

Rainfall Variability

Obviously, there are many farmer strategies for manipulating the crop/climate interaction that is so important for rainfed agriculture. The kenaf-rice system common in the paddy land in the central part of the region is essentially a risk-reducing strategy employed by farmers under conditions of variable rainfall. In dry years when rice planting is delayed or sometimes not even possible, farmers can leave the kenaf in the field to increase yield and thus obtain some compensation for the loss of the rice. Conversely, in wet years kenaf yields are lower due to early harvesting but this is balanced by increased rice production.

Pests

Pest control strategies for rice commonly employed by farmers are essentially a manipulation of the annual-crop/farm-family subsistence interaction. Paddy crabs, small insects, birds and other potential rice pests are important sources of food for Northeastern farm families and gathering these products from the rice fields obviously has important implications for plant protection. Pesticides are generally not used on rice because of their adverse affect on the natural fish populations in the paddy fields that are a major source of subsistence protein in the region.

Variable Market Prices

The on-farm/off-farm interaction is often manipulated to maintain price levels received for agricultural produce. For example, the marketing of silk in Muang Suang District of Roi Et is closely integrated with the high level of off-farm employment in that area. Silk is produced in the villages by the remaining work force, often elderly females and is marketed by the seasonal

off-farm labor force who sell it at a premium price in Bangkok when traveling to work there.

FARMING SYSTEM BASED RESEARCH SOLUTIONS TO ANNUAL-CROP IMPROVEMENT

It would be untrue to state that all the technologies being developed by NERAD (Pisone, 1987) were designed in line with a specific farmer strategy. However, now that an understanding of the more important farmer strategies has been gained, it is possible to explain why some of the technologies are successful and being adopted by farmers while others, although technically and economically sound, are not popular with the farmers. In addition, the understanding gained has important implications for future FSRE work in terms of helping to identify relevant research topics associated with key farming system interactions as defined by farmer strategies.

The remainder of this paper will therefore describe some of the NERAD-developed cropping system technologies in terms of their symbiotic association with important farm system interactions and their implications for future research priorities.

1. Manipulation of soil-water/soil-nutrient interactions.

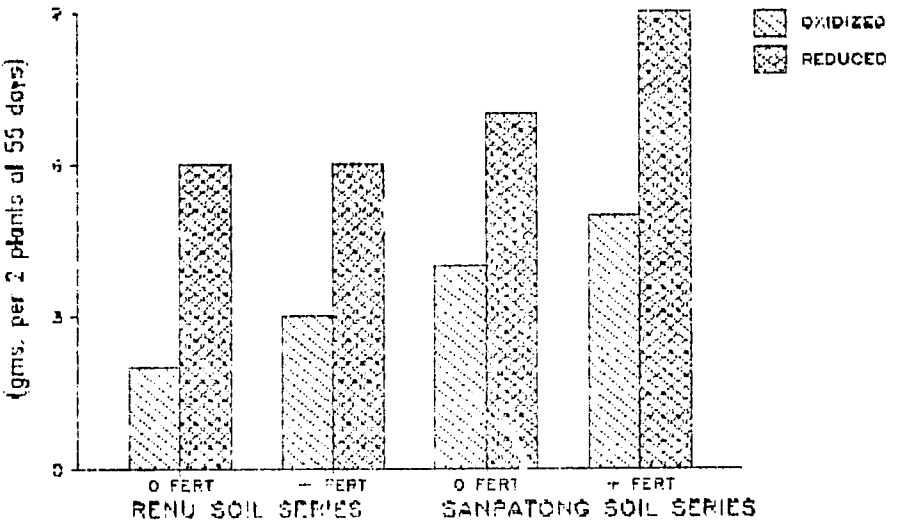
NERAD research has demonstrated significant improvements in rice growth (Figure 2) by using soil submergence to produce reduced conditions which enhance nutrient availabilities (Ragland, 1986). The effect is described by the following two equations:

1/ $$Fe(OH)_3 + 3H^+ \longrightarrow Fe^{2+} + 3H_2O$$

2/ $$Fe(H_2PO_4)_3 \longrightarrow Fe^{2+} + 3H_2PO_4$$

This property is traditionally exploited by farmers who construct earth-lined bamboo weirs across small waterways to divert water into their paddies to keep them submerged. NERAD has been addressing this opportunity by the construction of permanent diversion weirs on the seasonally-dry creeks that criss-cross much of the Northeast and which, during periods of rain, drain away up to 70 percent of the water that would otherwise be available to the rice. The objective of these weirs is to replace the farmers temporary weirs with permanent structures that don't wash out each year and which also allow for improved water control.

Figure 2. The effect of oxidized and reduced soil conditions on rice growth for two soil series.

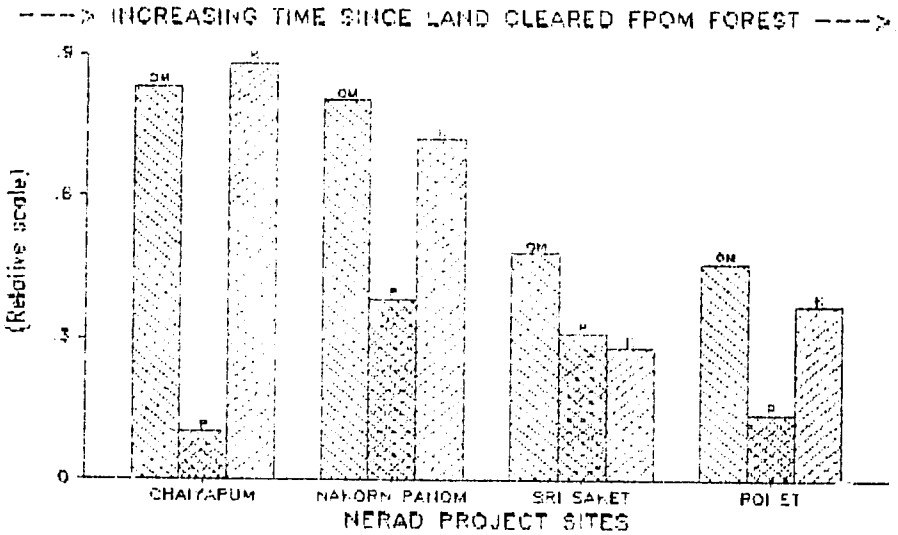


2. Manipulation of the annual-crop/soil-nutrient interaction.

Both of the major annual crops grown in the Northeast are traditionally cultivated year after year with little or no fertilizer application. Both are extremely efficient at removing nutrients from infertile soils; submerged rice due to its ability to grow under reduced, water-logged conditions and cassava by virtue of its physiological response to nutrient stress whereby it maintains leaf nitrogen levels and thus photosynthetic activity at the expense of leaf area index (Cock, 1983). Very little crop residues from either crop are returned to the soil; cassava due to its high harvest index (Cock, 1983) and rice because most of the straw is removed as cattle feed by the livestock/crop interaction. The result is that traditional annual crop production in the Northeast has been eroding the farm-system resource-base. This is clearly illustrated by comparing the soil fertility levels of the NERAD project sites in terms of the length of time under continuous annual cropping since each site was opened from primary forest (Figure 3).

Because of the limited availability of animal manure, the limited production potential for compost and the high cost of chemical fertilizer, attention within NERAD has turned to green manuring as the only feasible, low-cost means of manipulating the annual-crop/soil-nutrient interaction to give significant soil

Figure 3. Soil fertility levels in the NERAD Project sites.

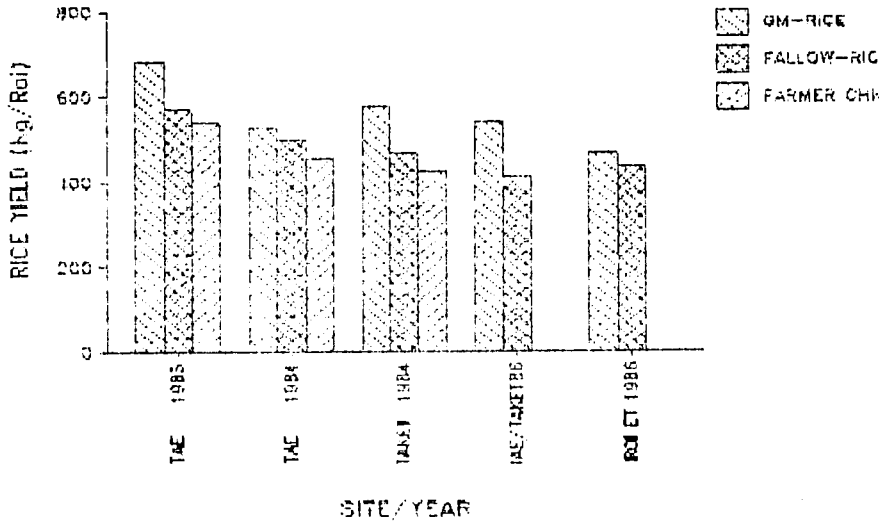


improvement on a large scale. Results of the trials presented in Table 2 and Figure 4 show yield increases due to green manure in the range of only 5 to 20 percent. Farmer interest is very high, however, with significant adoption already occurring in Sri Saket and Roi Et where soil fertility levels have declined furthest.

Table 2. The effect of green manure on rice yields in Kg. per rai for the NERAD cropping system trials, 1983-1986.

SITE	YEAR	G.MANURE CROP	No. REPS	TRIAL TYPE	GRN.MAN -RICE	FALLOW-RICE	FALLOW-FRM CHK
TAE	1983	COWPEA	5	ON-FARM	684	569	539
TAE	1984	COWPEA	10	ON-FARM	526	499	455
TAKET	1984	COWPEA	5	ON-FARM	575	464	421
TAE/TAKET	1986	COWPEA/SES	18	MLT/LOC	543	408	N/A
ROI ET	1986	VARIOUS	10	ON-FARM	464	435	N/A

Figure 4. The effect of green manure on rice, NERAD cropping system trials, 1983 to 1986.



Green manuring is necessary because soils in the Northeast are extremely infertile (Table 3). Unfortunately, this gives rise to the problem that it is often impossible to establish satisfactory stands of green manure crops without the use of fertilizer,

Table 3. Soil fertility scores for the soils of South East Asia (after Ragland, 1984).

	AREA	RELATIVE SCORE
1.	India, Godavari-Krishna.	+1.76
2.	West Malaysia, Kedah-Perlis.	+1.48
3.	Bangledesh, Ganges.	+1.27
4.	Bangledesh, marginal zone.	+0.57
5.	Bangledesh.	+0.54
6.	Bangledesh, Bramaputra.	+0.43
7.	Thailand, Bangkok plain.	+0.26
8.	Thailand, southern region.	-0.11
9.	Thailand, upper central.	-0.30
10.	Sri Lanka, wet and intermediate zone.	-0.33
11.	Thailand, inter-montane area.	-0.33
12.	West Malaysia, east coast	-0.99
13.	Sri Lanka, dry zone.	-1.58
14.	**NORTHEAST THAILAND**	**-3.26**

which would generally be unacceptable to farmers. Once again, a clue to solving this problem can be obtained from an understanding of traditional farmer strategies. In this case, it may be possible to obtain a satisfactory green manure crop by planting it in the same fields that receive the cattle manure that year under the farmer practice of rotating the animal-manure applications, discussed previously. By this means, it may be possible to permanently sustain or even increase the soil fertility improvement from animal manure by the practice of green manuring.

Alternatively, it may be possible to obtain adequate green manure crops without fertilizing by the careful screening of candidate materials. This work was initiated within NERAD in 1986 by the Department of Land Development with the objective of passing on the promising varieties thus identified to the Farming Systems Research Institute for on-farm testing (Table 4).

Table 4. Results of NERAD green manure screening trials. Nong Kaew, Roi Et, 1986.

GREEN MANURE CROP MATERIAL	YIELD (Kg/Rai)		% INCREASE OVER CONTROL
	G.M. CROP	RICE	
COWPEA	4352	479	10
RED COWPEA	1836	446	3
BLACK BEAN	3728	482	11
SWORD BEAN	2208	449	3
FALLOW (CHECK)	-	435	-

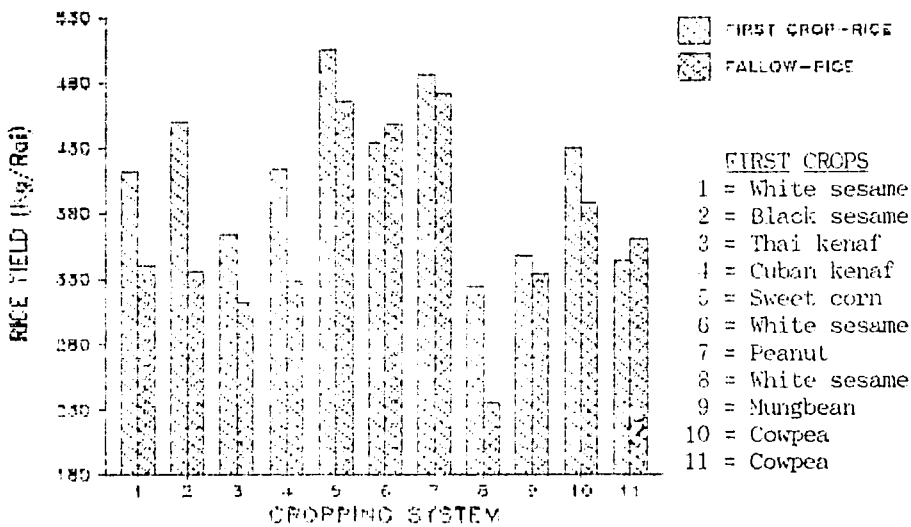
NERAD's on-farm trials also identified a variety of Sesbania (rostrata) obtained from the International Rice Research Institute that appeared to have considerable promise as a pre-rice green manure crop for the Northeast due to its ability to nodulate and grow well under acid, saline and water-logged conditions and because of its apparent lack of serious pests in the vegetative stage. Trials to date indicate that sesbania is a better green manure crop under wet conditions but that cowpea and blackgram tend to perform better under dry conditions. Unfortunately, at the time of planting there is no way of predicting the future climatic conditions and hence choice of the most appropriate green manure crop is often difficult. A possible means of overcoming this problem, might be the use of a sesbania, cowpea and blackgram mixed crop to test its potential for off-setting the uncertainty from climatic factors.

3. Manipulation of crop/crop interactions.

Detrimental interactions between component crops in sequential cropping systems, such as pest and disease build-up, allelopathy, etc. are now well recognized and documented (Trenbath, 1976; Litsinger and Moody, 1976). It has also been shown that, with correct management, their negative impact on the system can be avoided. Similarly, beneficial interactions can also be identified and, with careful manipulation, they have the potential for improving the performance of the whole system.

Beneficial interactions can be demonstrated that increase yields of the annual subsistence rice crop, the heart of the Northeast farming system. Various pre-rice crops have been tested by NERAD over the past 4 years and have given somewhat variable results in terms of yield and cash returns. As shown in Figure 5, however, the yields of the following rice crop are increased in almost every instance by the inclusion of a first crop in the system.

Figure 5. Residual fertility effects of a first crop on a following rice crop, NERAD cropping system trials, 1985.



This effect of residual fertility often does not show up on the better buffered, high-clay, rice soils of other regions of Thailand. Farmers in the Northeast, however, are well aware of the effect and this may explain why they are always willing to

participate in pre-rice crop trials even if the chances of complete crop failure are high. The implications for research are that current fertilizer recommendations based on component crops are inadequate for cropping systems on the poorly buffered, low C.E.C., sandy soils of the Northeast. Trials need to be conducted to establish recommendations that optimize the performance of the entire system rather than each component individually.

4. Manipulation of crop/fish interactions.

Research results from both on-farm and experimental station trials within NERAD have shown impressive rice yield increases due to the stocking of fish in the rice paddy (Figures 6 and 7). Unfortunately, the nature of the interaction between fish and rice is still not properly understood and cannot, therefore, be manipulated to optimise the performance of the entire fish/rice system. Various hypotheses have been advanced to explain the effect including: improved pest and disease control, fewer weeds, soil nutrient effects, the physical effect of fish on the rice plant and its root zone, improved water management and improved cultural care of the rice, but the effects of each have not yet been quantified. Joint research between the Department of Fisheries (DOF) and the Department of Agriculture (DOA) was initiated in 1986 in order to determine the true nature of the rice/fish interaction responsible for the increased rice yields.

The data obtained (Table 5) are far from conclusive. They do show, however, that the yield improvements are due to an increase in grain weight which was significantly different for plots with and without fish and for different fish stocking rates. The results tend to disprove the theory that increased yields are due to the fish stimulating tillering as there are no significant differences for this component of yield.

Table 5. The effect of fish on the yield components of rice, NERAD trials, Khon Kaen Rice Station, 1986.

COMPONENTS OF YIELD	NUMBER OF FISH RELEASED PER RAI				
	0	800	1000	1200	C.V.(%)
100 GRAIN WT(gms)	2.60	2.66	2.68	2.73	19.9
PLANT HEIGHT(cms)	141	144	144	146	2.6
TILLERS/HILL	7.63	7.40	7.29	8.10	2.4
PANICLES/HILL	6.52	6.20	6.44	6.46	7.9
GRAINS/PANICLE	3630	3801	3653	3954	10.9
UNFILLED GRAINS (%)	0.76	0.72	0.77	0.77	12.1

Figure 6. The effect of fish on the yield of rice, NERAD trials, Khon Kaen Rice Research Station, 1986.

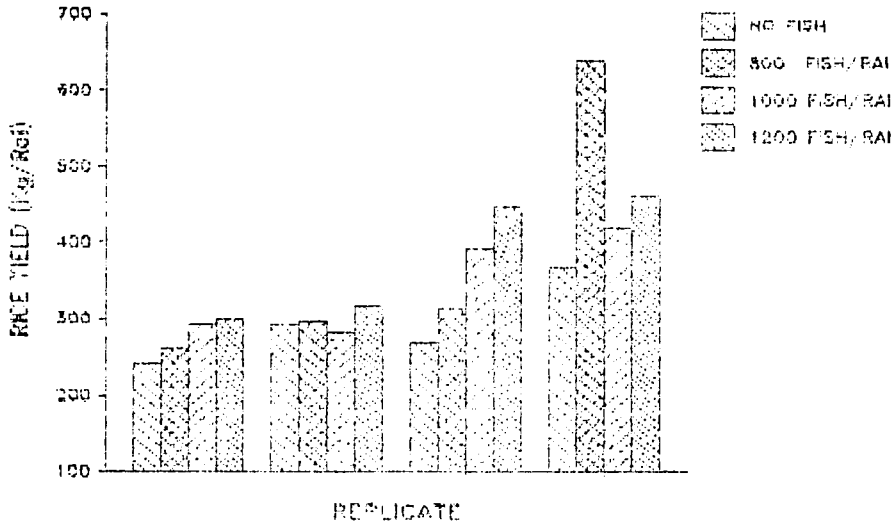
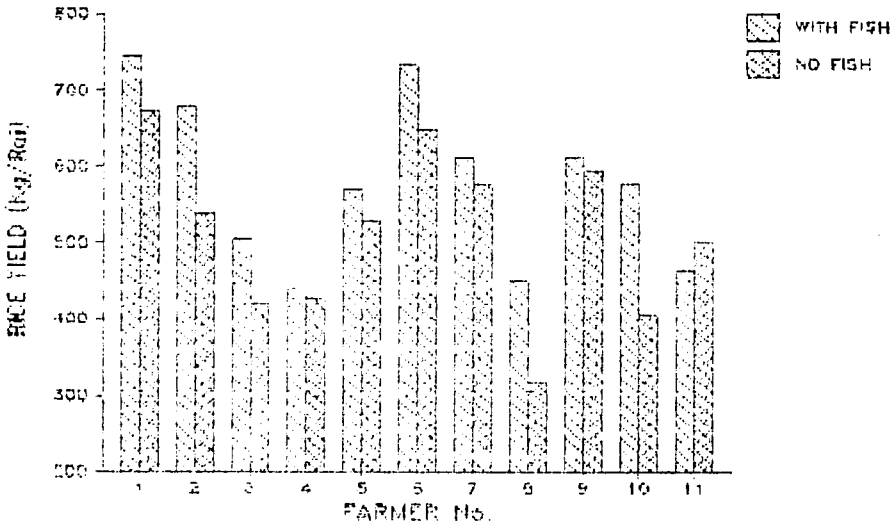
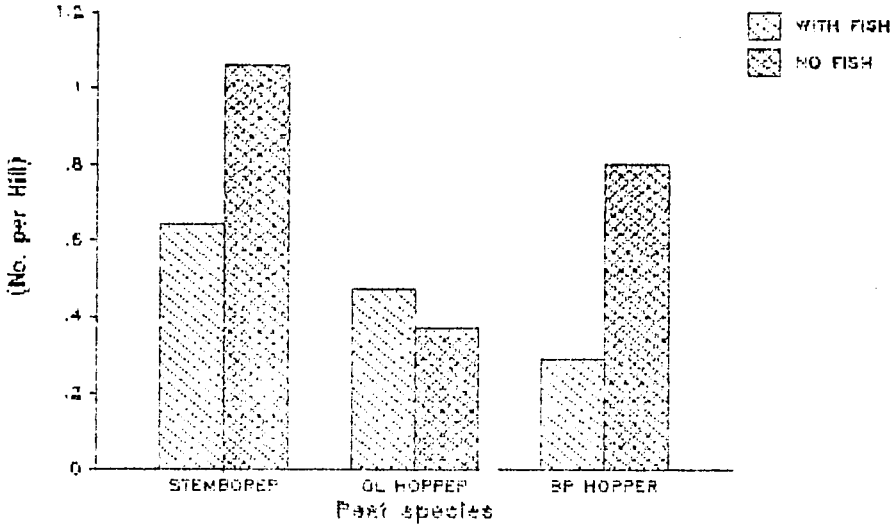


Figure 7. The effect of fish on the yield of rice, NERAD on-farm trials, Sri Saket, 1986.



Results from NERAD's on-farm research on fish in the paddy are presented in Figures 8, 9 and 10. These trials concentrated on the effect of fish on pest, disease and weed populations in rice. Once again, no conclusive evidence was obtained but the results do raise a number of interesting hypotheses that will require research attention in the future.

Figure 8. The effect of fish on rice insect pests, NERAD on-farm trials, Sri Saket, 1986.



The results show that the presence of fish can reduce the incidence of some pest, disease and weed species by up to 50 percent. The likely effect of this reduction on yield is questionable for some pests such as the brown planthopper because of the low pest populations involved. However, in other cases such as the stemborer and crown rot, the reduction in pest populations was sufficient to significantly effect yield. In these instances the mechanism by which the fish reduce pest levels is difficult to explain as there are no apparent stages in the life cycle of the pest when it might be susceptible to direct predation by fish.

Figure 9. The effect of fish on rice pathogens, NERAD on-farm trials, Sri Saket, 1986.

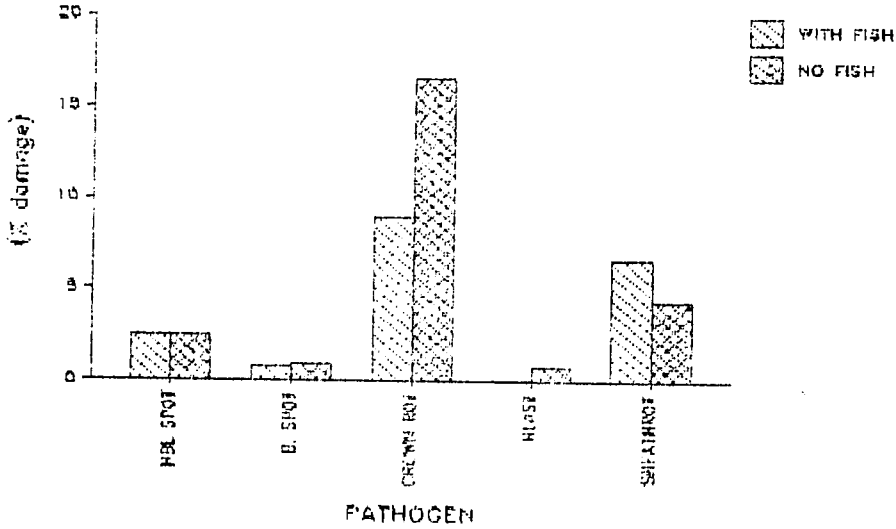
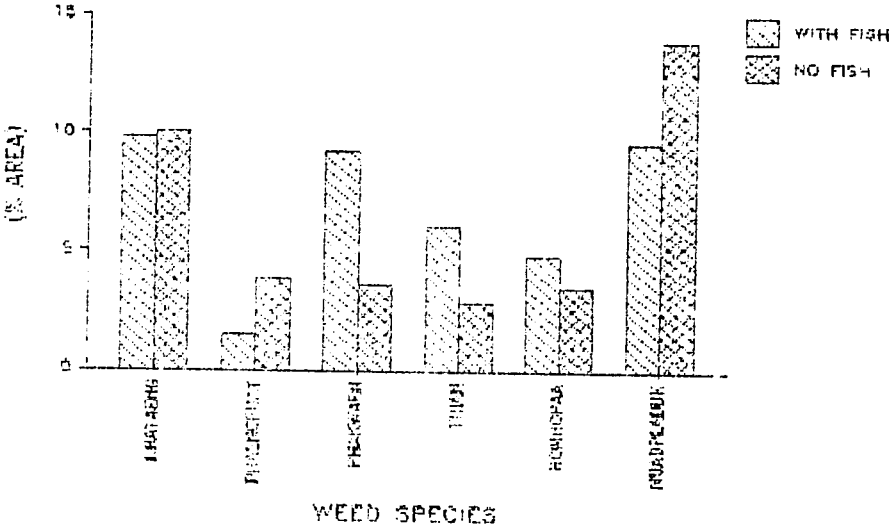


Figure 10. The effect of fish on rice weeds, NERAD on-farm trials, Sri Saket, 1986.



Further research on the life cycles of the key pests and a study of the possible indirect effects of the fish such as changes in pest habitat, host plant attractivity, etc. are needed. This will ensure that research results are produced that add to the understanding of the interactions that occur between fish and rice so that in the future, the potential benefits can be manipulated to improve the performance of the system as a whole.

CONCLUSIONS

Farming systems, especially when they have evolved under highly stressed conditions, such as those found in Northeast Thailand, are extremely complex with many interactions occurring among their component enterprises. Farmers recognize these interactions and manipulate them in order to optimise the performance of the entire farm system. Synergistic, or mutually beneficial interactions between annual crops and other components of the farm system can be identified with the help of an adequate understanding of the farmer strategies currently being followed. The purpose of annual crop based FSRE approaches is to develop appropriate component crop technologies based on an understanding of the important synergistic interactions occurring within the agro-ecosystem. It is not the role of FSRE, however, to manipulate the individual components of the farm. This is the job of the farmer, as he alone has the sufficiently-detailed knowledge of his farm agro-ecosystem necessary to manipulate its components in order to optimize the performance of the entire system in line with his individual goals and objectives.

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APPENDIX

The following NERADICS Working Papers are available on request from the Project Director:

NERADICS Problem Definition Series

P1 Effects of Paddy-bund-planted Eucalyptus Trees on the Performance of Paddy Field Crops. Craig, I.A. and Wasunan, S., 1987. (English)

P2 Overview of Rainfed Agriculture in Northeast Thailand. Craig, I.A. and Pisone, U., 1987. (English)

P3 The Upper Paddies in Northeast Thailand: The Current Situation and Implications for Development. Craig, I.A., and Baker, G.P., 1986. (Thai and English)

P4 Current Pest Management Problems Facing Farmers in Northeast Thailand: Key Research and Development Priorities. Katanyakul, W., Amaritsut, W., Keerati-Kasikorn, M. and Craig, I.A., 1987. (English)

P5 Problems and Opportunities for Farming System Based Annual Crop Development in Northeast Thailand. Craig, I.A., 1987. (English)

NERADICS Technology Documentation Series

T0 Executive Summary: NERAD Promising Technologies. Thamabood, S. (Editor), 1986. (Thai)

T1 Direct Sown Rice: a Cropping Systems Technology for the Upper Paddies in Northeast Thailand. Craig, I.A., Whattanabhuti, W., Sukapong, C. and Netpichit, W., 1986. (Thai and English)

T2 Cooperative Buying Groups in Thailand: Results of a Social Experiment. Meyer, A.L. and Infanger, C.L., 1987. (English)

T3 Modified Shallow Wells: a Farmer Developed Technology for Northeast Thailand. Craig, I.A., Phensupha, N. and Ragland, J.L., 1986. (English)

T4 Pre-rice Green Manuring: a Technology for Soil Improvement Under Rainfed Conditions in Northeast Thailand. Craig, I.A., 1987. (English)

T5 Papaya Ringspot Virus: Cross Protection for an Important Subsistence Crop in Northeast Thailand. Gonsalves, D. and Prasartsri, V. (English)

NERADICS Methodology Documentation Series

M1 A Cropping Systems Technology Development Process: the NERAD Model. Craig, I.A., Sukapong, C. and Suratikul, S., 1986. (Thai and English)

M2 Triage: a Methodology for Screening Agricultural Technologies and Prioritizing Research and Extension Activities. Craig, I.A. and Sukapong, C., 1987. (Thai and English)

M3 NERAD Project Agricultural Development Information and Coordination System (NERADICS): A Project Description. Hopkins, J., 1987. (English)

M4 The Rapid Assessment Technique (RAT): a Procedure for Identifying Farmer Problems and Development Opportunities. Alton, C. and Craig, I.A., 1987. (Thai and English)

M5 Key Characteristics of the NERAD Full-cycle, Integrated Development Models. Songlin, R., 1987. (Thai)

M6 The NERAD Logical Framework: a Project Design Summary for Planning, Monitoring and Evaluation. NERAD, 1987. (English)

M7 Crop Protection and IPM for Rainfed Cropping Systems in Northeast Thailand. Amaritsut, W., Prasartsri, V. and Craig, I.A., 1987. (English)

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