PROPOSAL OF METHODOLOGY TO IMPROVE LIMITING FACTORS OF RICE CROPPING SYSTEMS IN SATHING PHRA AGRARIAN SYSTEM

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Abstract

This presentation will concentrate on the original methodology of the cropping systems research started in 1984. The research aims at improving the limiting factors of traditional rice cropping systems of Sathing Phra agrarian systems. This research is the second stage of a 1982–1983 study of Sathing Phra agrarian system which was a preliminary diagnosis necessary to define priorities of research and targets to improve the different farming systems of Sathing Phra. The results from this first stage demonstrated the limiting factors and characteristics of rice cropping systems according to their agro–ecological localities and farming system types. Poor physical structure and low chemical fertilily of the soil and weed control problems (especially with wild rice in dry–seeded paddy) are the most important limiting factors that need to be improved. Fundamentals of cropping system analysis and their use to study technical improvements are discussed. A necessary double–level analysis of this methodology includes (i) a systemic analysis to follow the effects of technical improvements on the system efficiency and reproducibility and (ii) an analysis of the interactions between the different elements of a cropping system in order to define the optimum conditions for employment of technical improvements in technical routes that fit the agro–ecosystem characteristics and farming system types. A program of research based on those two levels of analysis is then presented. In this research program we assume that the cultivation of legume crops grown with suitable technical routes, during the variable fallow durations between rice crops, may help improve soil physical and chemical conditions as well as weed control strategies of Sathing Phra rice cropping systems.

1. INTRODUCTION

The concepts of Farming Systems, Cropping Systems and Cropping Patterns are now generally accepted as a useful tool for agricultural development, but are also very confused ones. In south Asia, the introduction of short duration rice varieties has made multiple cropping patterns the principal aim of Cropping Systems Research Projects (1, 2). As it became necessary to take animal raising into account, Cropping Systems

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Projects were transformed into Farming Systems ones. The main criticism one can point out about this procedure is that this research tends to propose entirely new farming systems that are very efficient but usually unsuitable to farmers' conditions because of a lack of understanding of the existing Agrarian Systems. This understanding includes the defining of the relationship between the ecological environments, the systems of production, and the social organization. It requires a gradual systemic analysis which starts from the plot level (cropping systems) to the farm unit level (farming systems) and up to the local socio-economic contexts (villages–region) (6).

The aim of this note is to present the general methodology of a Cropping Systems Research. This research is a part of a Thai–French Farming Systems Research Project which has been undertaken in Sathing Phra district of Songkla Province in Southern Thailand since 1982 by Faculty of Natural Resources, Prince of Songkla University. Followings are the features of this Cropping Systems Research.

1) The priorities of research to be carried out were determined after a two year study of the Sathing Phra agrarian systems.
2) The aim of the research is not to test cropping patterns, but to improve limiting factors of existing rice–based cropping systems in Sathing Phra.

2. DEFINITIONS OF RESEARCH PRIORITIES AND TARGETS

The French National Research Institute of Agronomy defined a cropping system as a succession of crops and cultivation techniques uniformly performed on a plot of land to obtain a crop production that meets the farmer's objectives. (3).

Traditional rice cropping systems found in a given area express the farmers' technical choices to reach their goals in different agro–ecological environments according to their socio–economic conditions and strategies. A deep knowledge of (i) the agro–ecological units and (ii) the different types of farming systems functioning (long–term strategy and daily tactics according to the characteristics of the production system) were necessary in order to point out the limiting factors to be improved and to define targets in a farming system perspective. This study had been successfully carried out during the first stage of our Farming System Project, from 1982 to 1984 (7,8,9).

Table 1. summerizes some data concerning traditional cropping systems of Sathing Phra according to the characteristics of the main cultivated agro-ecological units, with baselines of the different types of farming systems surimposed. These data show that the characteristics of cropping systems found in a given agro–ecological unit depent not only on the unit's characteristics but also on the type of farming systems to which the cropping systems belong.

In unit I and II, the ecological conditions are so constraining that the farmer's technical choices depend more on ecological constrainsts, according to the year's rainfall pattern, than on the characteristics of their own farming systems. In those units, beside the absence of water control (low irrigation and drainage facilities), the main limiting factors of cropping systems are (i) low fertility and weed control in unit I, and (ii) land preparation in heavy textured soils with low organic matter content in unit II.

Table 1 : Croppings systems characteristics of Sathing Phra area, according to different agro–ecological units with farming systems types surimposed.

AGRO–ECOLOGICAL UNITS CHARACTERISTICS			CROPPING SYSTEMS CHARACTERISTICS	CHARACTERISTICS OF THE MAIN TYPES OF FARMING SYSTEMS
Denomination	Soil characteristics	Main constraints for crops		
UNIT I : Villages area on sandy bars (< 10 % of the cultivated area)	– Upper land topography – Sandy soil. – pH < 5.1. – P.K. very low. – C % < 0.7 %	– Low fertility – Weed control. – No water control.	– Gardens, dryseeded rice beds mainly. – Crops during pre–rainny season (Mungbean, peanuts, cucumbers...). – Simple technical routes for rice	A – Low ratio of cultivated land per labor (1.7 to 2 rai/labor). – Dominance of non–rice cultivation activities : Palm trees climbing temporaries jobs.
UNIT II : Paddies without suger palm trees (**Borassus flabellifer** Linn.)	– Lowland plots flooded most part of the year. – Clayey to heavy clayey soil. – pH ≤ 5.3. P very low – C % < 1.2 %.	– Land preparation. – Uncontrolled submorsion.	– Rice exclusively – one crop a year. – High diversity of technical routes according to rainfall conditions. – Use of local varieties adapted to deep water. – Early land preparation. – Early seedbed planting–hand weeding–thinning transplanting, Determinant.	B – Rice cultivation principal income and activity (few other opportunities). – Medium ratio of cultivated land per labor (3.7 to 4.5 rai/labor). – Low work productivity
UNIT III : Paddies surrounded with sugar palm trees (**Borassus flabellifer** Linn.)	– Various textured soils from sandy clay to clayey according to the microtopography. – pH ≤ 5.5, C % < 1 %, P very low.	– Weed control – Land preparation. – Low fertility. (low water control)	– Rice exclusively and sugar palms trees (on interaction between those activities). – Ecological conditions less determinant than farming systems conditions. – Wide range of suitable technical routes (possibilities of regulation). – Various cropping patterns : generally 1 crop a year sometimes 2–3 crops a year (rice/mungbean/cucumber) if water is available.	C – High ratio of cultivated land per labor (> 5 rai/labor). – High work productivity. – Adoption of new varieties of rice (R.D. 7, R.D. 5).

In unit III, ecological conditions are less significant than the characteristics of the farming systems. Due to various textures and topographies, and a better control of drainage, farmers have a wider range of techniques to choose. But these technical choices vary between types of farming systems, In type A farming systems, technical choices for rice cultivation depend on others opportunities of work (palm trees climbing, temporary employments, elc.) which represent their principal income. In type B, where rice cultivation is the main income and people's work opportunity, cultivation techniques are based on a full employment of the labor, while the priority of farmers from type C is to look for the most profitable choices (even non-cultivation of some plots, for example). Whatever the farmer's technical choices, weed control (especially wild rice in dry-seeded paddies), land preparation and soil fertility are the most important limiting factors of cropping systems located in unit III.

In conclusion, in this area where the crop-livestock association has been deeply modified (fewer and fewer cattles on the farms and the presence of some small farms specialising in raising ducks or chicken), improvement of rice cropping systems is one of the priorities for improving Sathing Phra farming systems. We assess that the priorities of research to improve rice cropping systems are :

1) land preparation in unit II and III,

2) weed control, especially wild rice control in dryseeded paddies from unit III,

3) soil fertility, especially in unit III and less so in I.

The target farmers are principaly from type B and type C. For type A (and a part of B), the main improvement does not concern rice cropping systems but the sugar palm industry. A specific program has been started on this field of research.

3. FUNDAMENTALS OF CROPPING SYSTEM ANALYSIS TO STUDY THE EFFECTS OF TECHNICAL IMPROVEMENTS.

Figure 1. shows a simplified representation of the functioning of a cropping system. Two complementary levels of analysis must be carried out to study the accuracy of technical improvements performed on a given cropping system. These levels include :

1) a systemic analysis to follow the effects of technical improvements on the efficiency and reproducibility of the system, and

2) an analysis of the interactions between the different elements of a cropping system in order to define the optimum conditions for employment of technical improvements.

Considering the systemic level, the system's efficiency is characterized by the ratio between output and input of the system. Net income is a common ratio to measure the efficiency of a cropping system. Total dry matter production or yield expresses the efficiency of the system to transform solar energy. Some other specific ratios such as fertilizers efficiency (total yield/amount of fertilizers), labor productivity (total yield/time allocated to the system) may also be relevant.

It is not sufficient to design technical improvements which increase the efficiency of the system. It is also necessary to follow the residual effects of technical improvements on the state of the system (soil organic matter content, soil structure, pests population, weed population, etc.) (5). This state should be adequate to maintain the long term

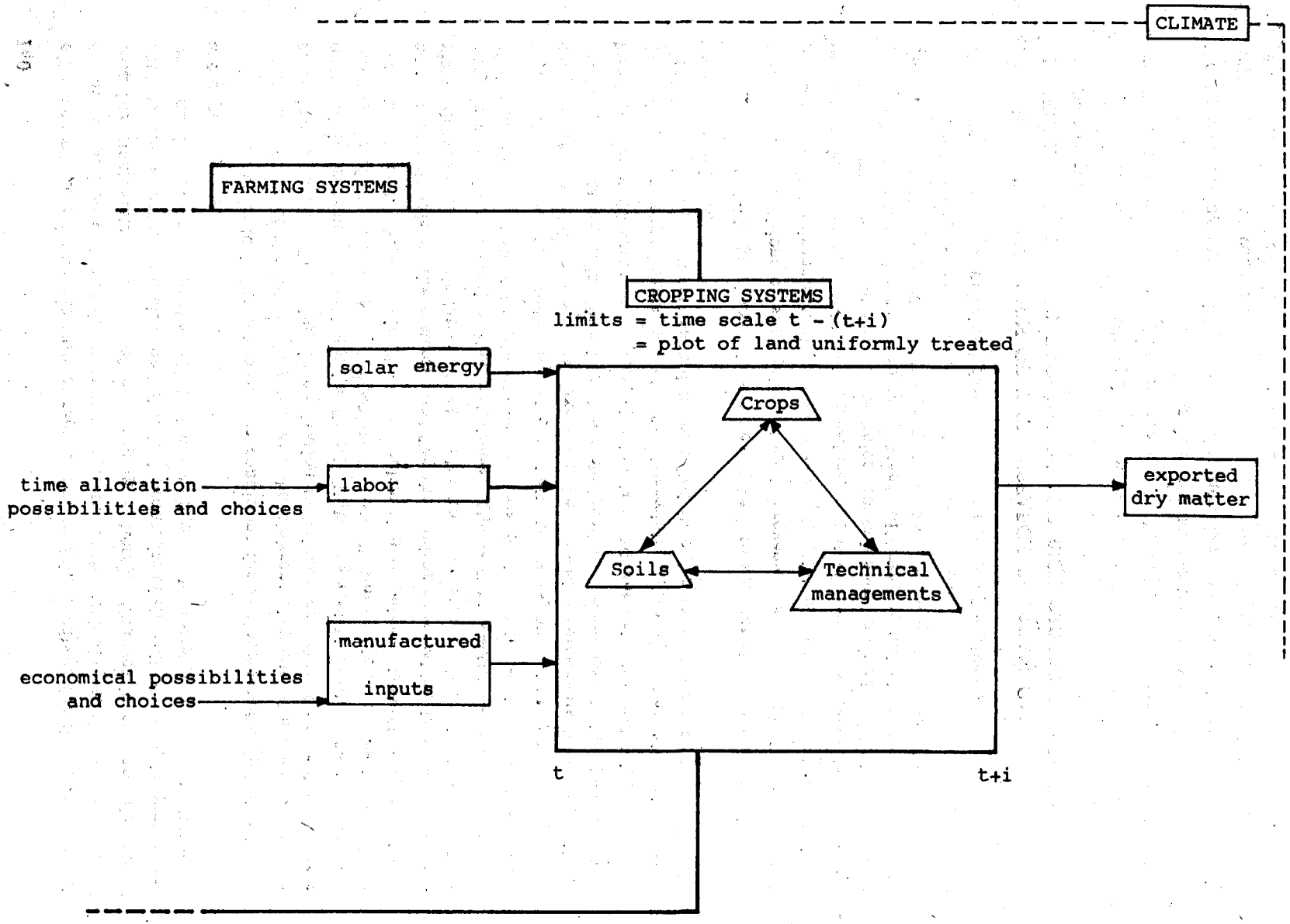


Figure 1. Simplified diagram of the functionning of a cropping systems.

efficiency of the system: the system reproducibility (5). Analysis for this must consist of the comparison of the initial state of the system (at the beginning of a cropping pattern) with the final state (the end of a cropping pattern). Changes in soil organic matter content, soil structure, physical and chemical properties of the soil, weed seeds population, pest and desease stocks are the principal parameters to characterize the reproducibility of a cropping system.

In order to define the optimum conditions for employment of technical changes, we need a study of the interactions between the different elements of a cropping system at each crop level. Focussing on cultivation techniques, one should never forget that a technical improvement should not be directly linked to a yield result. Such an abusive relationship often leads to extend "technical receipts" unsuitable to the real diversity of cropping systems. As shown in Figure 2, a cultivation technique, depending on the climate and the initial state of the system, modifies the environment which in turn affects the yield elaboration. This latter effect is also, to some extent, determined by the later climatic conditions and cultivation techniques. Under field conditions, the potential level of dry matter, determined by climatic components, is limited by environmental resources that affect the Leaf Area Index and Net Assimilation Rate, The yield elaboration process, characterized by yield components, expresses the successive agreements between environmental resources (modified by cultivation techniques) and plant population demands. The knowledge of yield components determination is useful not only for explaining this latter dynamic during experiments, but also for determining when and what kind of environmental and plant parameters should be recorded in order to evaluate the effects of cultivation techniques.

All field experimentations have to take into account these interactions in order to define the conditions of application of an improvement according to (i) the state and properties of the environment, (ii) the most probable climate, and (iii) the other techniques performed on the crop. With this procedure, technical routes to create desirable states of environments can be proposed. A technical route is a well ordered and logical succession of techniques performed for a crop (4). Many different technical routes may lead to similar results. However, figures 1 and 2 show that whatever the lever of analysis used, all improved technical routes or changes in cropping patterns have to be adapted to the various agro–ecological units and farming systems types of a given area.

4. GENERAL PRESENTATION OF THE RESEARCH PROGRAM CARRIED OUT TO IMPROVE THE LIMITING FACTORS OF THE RICE CROPPING SYSTEMS OF SATHING PHRA.

The three main limiting factors pointed out above are closely linked. The quality of land preparation affects weed control. Likewise, weed control affects fertilizer responses and use by farmers. Therefore, we assume that crop rotation with legume crops grown during the variable fallow duration between rice and the use of suitable technical routes for each crop, may improve the physical properties of the soil and land preparation as well as "wild rice" control and soil fertility.

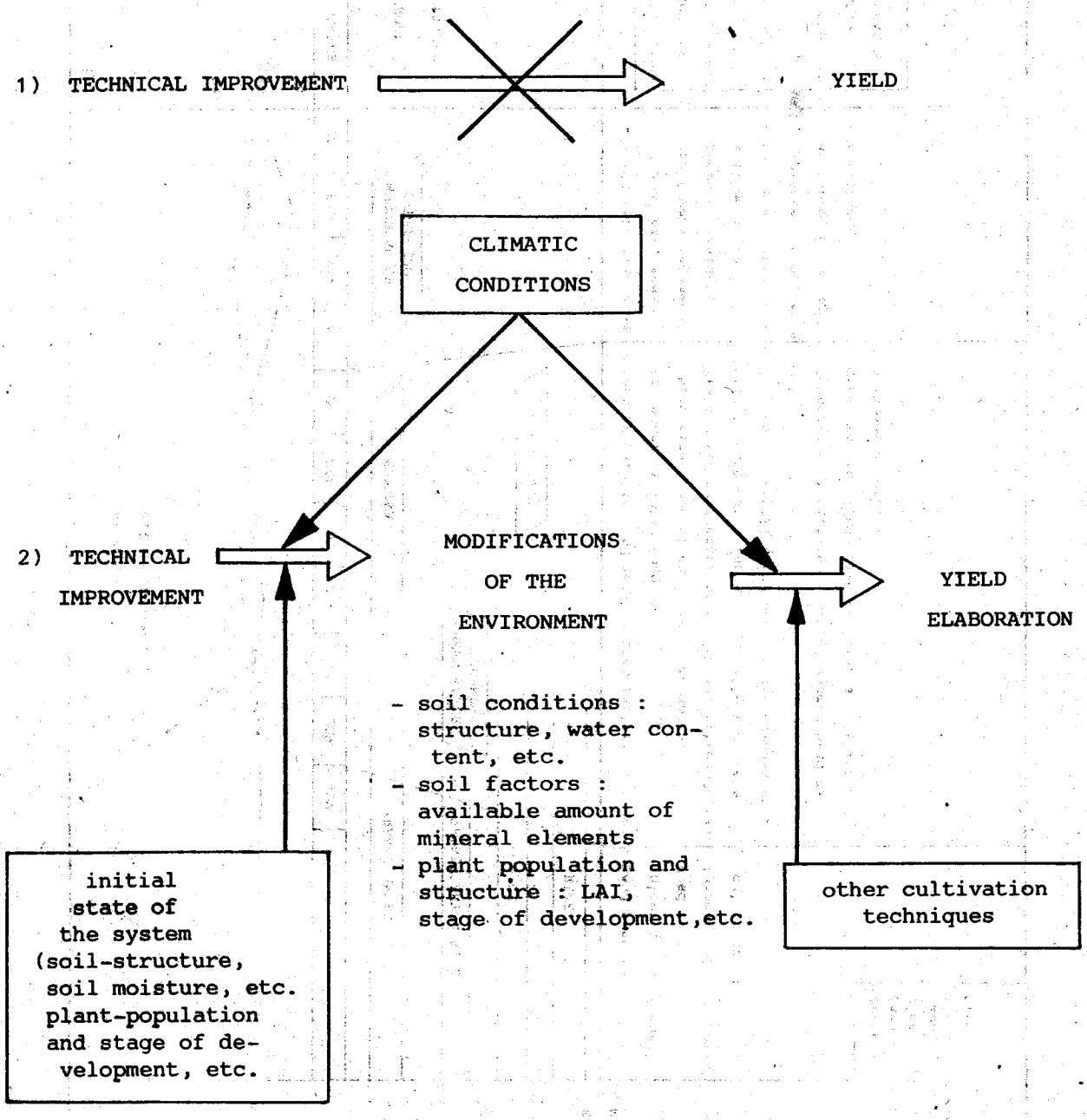
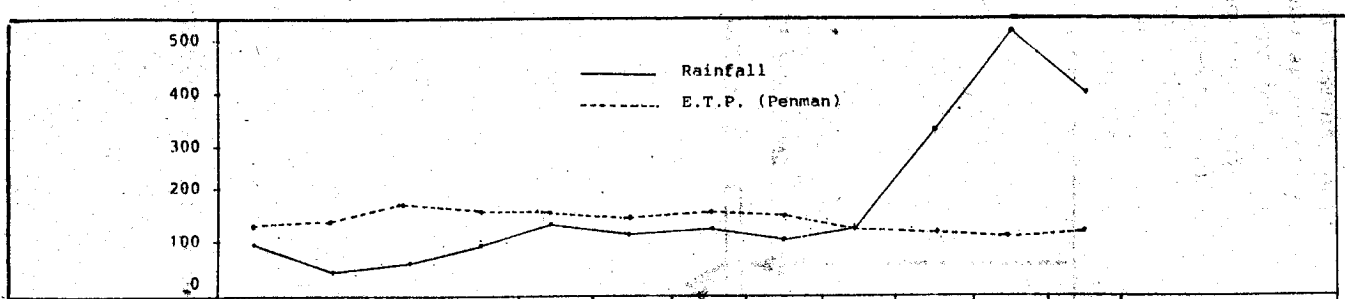


Figure 2. Fundamentals of analysis of the effects of technical improvements according to the interactions between the elements of the systems.



MONTHS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CROPPING PATTERNS	MUNGBEAN OR OTHER CROPS				MUNGBEAN					TRANSPLANTED RICE		
									GREEN MANURE LEGUMES	TRANSPLANTED RICE		
					MUNGBEAN					RICE		
										RICE		

INTERACTIONS BETWEEN THE ELEMENTS OF THE SYSTEMS

CROP LEVEL RESEARCH

- Yield potentialities of mungbean, sesame and forage legumes grown on residual soil moisture.
- Land preparation and implantation patterns suitable for drought resistance.

- Land preparation and implantation patterns suitable to temporary water logging.
- "Wild rice" control patterns in mungbean.
- Field limiting factors of biological nitrogen fixation of mungbean. (inoculation, effect of water logging and fertilizers rates on nitrogenase activity).
- Comparison of different forage legumes used as green manure. (Sesbania, Crotalaria, Alysicarpus, Aechynomene etc.).

- Land preparation (plowing conditions)
- Weed control. (mechanical and chemical control).

SYSTEMIC ANALYSIS

- Residual effects of cropping patterns and technical routes on :
  - soil physical properties and structure,
  - chemical fertility and soil organic matter, and
  - wild rice populations.
- Efficiency ratio and reproducibility.
- Frequency of climatic events.

Table 2 : Summary of 1984-1985 research program carried out to improve the limiting factors of rice cropping systems of Sathing Phra. The two levels of analyses : systemic analysis and analysis of interactions between the elements of the systems.

This research is not a study of the productivity of different cropping patterns, but some cropping patterns and technical routes will be tested to improve the main limiting factors of existing rice cropping systems of Sathing Phra. The researches to be carried out are summarized in Table 2. At the crop level (analysis of the interactions between the elements of the system) we focus our work on land preparation and crop implantation, wild rice control and the effects of legumes on soil fertility. At a systemic level we study the residual effects of different cropping patterns and technical routes on the reproducibility and efficiency of the systems.

On farm experiments (principally farmers types B and C) using plots managed by researchers and farmers (10) will be implemented mainly in agro-ecological unit III (fewer in I and II). This research involves following research fields.

1) yield elaboration of legumes under different environments,
2) land preparation and physical properties of the soil,
3) wild rice ecology and control,
4) limiting factors of biological nitrogen-fixation,
5) soil fertility, and
6) climatology.

CONCLUSION

Diagnosis of the existing Agrarian System of a given area (uses and potentialities of agro-ecological units, functionning and typology of farming systems, and socio-economic context) is a necessary preliminary stage of Farming System Research. This initial work carried out in Sathing Phra by a small team (2 researchers) trained in multidisciplinary approaches pointed out the research priorities and their different targets. At this stage a real interdisciplinary (not multidisciplinary) research work may start because well defined questions must be answered integratedly.

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