DIAGNOSIS ON FARMING SYSTEMS FUNCTIONING AND FARMERS DECISION MAKING IN KANJANABURI PROVINCE: HYPOTHESES FOR IMPROVEMENT OF THE SUSTAINABILITY OF MAIZE-COTTON CROPPING SYSTEM.[1/]

ABSTRACT

The main objective of this agronomic survey carried out in 1991 among cotton producers in Kanjanaburi province was to identify, grade, and explain factors and conditions which are limiting yield optimization of maize-cotton relay cropping system. This approach analyses how constraints linked to, both bio-physical and socio-economic environmental conditions, are taken into account in farmers decision making process when managing their Agricultural Production System (APS).

The crop cycle-long monitoring of cultivation practices effects on plant population states is presented as a relevant tool to explain yield differentiation among farmers. Such a study leads to the design of adapted innovations in order to improve farmers' itineraries of techniques, optimize cotton production processes and boost the sustainability of their APS.

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1. INTRODUCTION

In the framework of the diagnostic – analysis of the DORAS research and development process, the historical approach and the farmer typology activities (NARITOOM C, 1992) generate an understanding of the technico-economic functioning of each main type of Agricultural Production Systems (APS) in the target area: tambon Tha Sao of Sai Yok district in Kanjanaburi province. They also lead to an appraisal of their respective ability to continue, or sustainability. These tools can then be used by the on-farm agronomist to understand farmers' practices and technical choices, according to the different management economic criteria that they see in their interest to optimize.

At this stage, the objective of the agronomic diagnosis is to analyze the consequences of these various farmer technico-economic choices on the crop production processes. Special attention is paid to the evaluation of the efficiency of the bio-physical processes and input management in comparison with local potentialities.

The agronomic diagnosis is carried out at the plot level and focuses on two of the main field crop productions in Kanjanaburi province associated in the maize – cotton relay cropping system[1] under rainfed conditions.

2. METHOD

2.1. BASIC PRINCIPLE: a comprehensive approach is necessary to explain farmer's practices.

A comprehensive approach is prefered to a description of observed situations which can not lead neither to relevant grading of limiting factors nor the design of adapted solutions to be tested.

The successive steps of the study are as follows:

(i) Observation and characterization of the various itineraries of techniques[2] performed by the farmers when managing their rainfed maize – cotton cropping systems,

(ii) Explanation of these farmers' technical choices in relation with the characteristics of the bio-physical environment (agro-ecological zonation KAOJARERN S, 1992) and the differentiated functioning of the APS (farmer typology: see NARITOOM C, 1992),

(iii) Identification of the potential yields for the target area, explanation of the yield differentiation within and between farmers' plots, and gradation of the sources of variation of the yield in order to identify and prioritize the limiting factors of the crop. This is done in relation with a network of on-farm exploratory experiments to investigate the effect of a priori key limiting factors: here the degree of pest control (CROZAT Y, 1988).

(iv) Propositions of relevant future improvements, through either on-farm (tests of innovative technical management for the whole maize-cotton cropping system) or on-station experiments, or extension (training) activities.

2.2. PRACTICAL IMPLEMENTATION OF THE AGRONOMIC SURVEY.

Based on a review of the secondary data and interviews with other researchers, extensionists or farmers, hypotheses coming from a direct assessment of limiting factors have been first established in order to be used as a guideline in the analysis of the yield elaboration process under farmer's circumstances as well as for the production of preliminary hypotheses to be tested (on farm experiments associated to agronomic survey). In a first attempt, crop protection practices, plantation density, varietal choice, planting date, duration of cotton in maize, fertilization and weed control were assumed as main limiting factors for cotton production in the regional maize – cotton based cropping system.

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[1] CROPPING SYSTEM = the succession of crops and techniques performed on a plot of land. It expresses the farmer's choice of plant population combinations to reach his objectives in a given natural and socio-economic environment.

[2] ITINERARY OF TECHNIQUES = a logical and well ordered combination of the techniques applied to a crop by the farmer to achieve his objectives (SEBILLOTTE, 1978).

Testing of these hypotheses has been carried out through an on-farm agronomic survey. A well-selected sample of very different plots, covering a wide range of various management practices in the area, has been monitored for both maize and cotton crops.

2.2.1 Sampling technique.

Preliminary knowledge at the Agricultural Production System (A.P.S.) level is necessary to analyse the technical output at the plot level, therefore the first sampling step focus on A.P.S. general functioning criteria. Priority is then given to the analysis of a wide range of cultivation practices, allowing to maximize the diversity of observed cropping systems, rather than on a sample representative of regional situations.

In a second step, one verifies that the sample can effectively cover the range of diversity of regional agrarian structures (APS size, types of farm equipment, etc...). This approach enables to understand the differentiation among the itineraries of technique performed, in relation with the specific constraints and potentialities at each A.P.S. level.

2.2.2 Surveying technique.

2.2.2.1. Gathering of general information.

A guideline, based upon open questions, is prepared and focus on the maize-cotton cropping system, other general informatioon on A.P.S. functioning being available from the farmer typology (NARITOOM C, 1992). The interviews are aiming at understanding the rationale of farmers' strategical choices, given their objectives and available means of production.

At the plot level, one studies the itineraries of technique usually performed on each plot (program of work planned by farmers) in relation with agro-ecological conditions or A.P.S. constraints in order to understand the main features of farmers' decision making processes.

2.2.2.2. Plots monitoring.

One plot per farm has been selected and monitored, from sowing to completion of harvest, for both maize and cotton crops. Itinerary of techniques as well as crop state have been followed up.

Plot couples, differing by only one factor of variation (when possible), have been established in order to test hypotheses concerning the efficiency of several cultivation practices (sowing date, varietal choice, plant density, etc...), or to study the effect of environmental conditions (soil type). Interpretation of the results has been performed by using the knowledge obtained from the on-farm experiments carried out in the same area in 1991.

Yield variations among surveyed plots has been interpreted by using the information collected during the whole crop cycles on plant growth stages linked to environmental conditions and farmers' cultivation practices.

The itinerary of technique recorded has been compared to the general work calendar planned by the farmer and explained in the framework of the specific circumstances of this crop year: climate, insect populations, etc...

3. RESULTS AND DISCUSSION

Maize-cotton relay cropping system in Tambon Tha Sao of Sai Yok district is characterized by a wide diversity of cultivation practices (see table 1).

Cultivation practices	Farmer plots		DOA Recommendations	
	mini.	maxi.	mini.	maxi.
Sowing date (day/month)	23/06	01/08	01/07	20/07
Sowing density (plant/ha)	13600	30400	16000	20000
Weeding (number of times)	1	5	2	3
Fertilization N-P-K (kg/ha)	19-0-0	55-55-31	35-35-35	75-75-35
Pest control (number of applications)	3	17	12	17
Intercrop duration (days)	20	60	15	40

Table 1 : Range of variation of cultivation practices performed on cotton crop by farmers in 1991 compared with Department of Agriculture (DOA) recommendations for the same area.

The observed range of variation has different origins. In fact, factors influencing farmer decision making have to be found at three levels:

(i) the **regional** physical and socio-economic environment,

(ii) the potentialities and constraints of the **APS** functionning for the maize-cotton cropping system.

(iii) the effect at the **plot** level of farmer practices on plant growth and yield differentiation.

The case of crop protection management, one of the main limiting factors for yield optimization, is used here to illustrate how the rationality of farmers' technical choices needs to be explained at different inter-related scales.

3.1. THE REGIONAL SCALE

3.1.1. *The regional physical environment*

3.1.1.1. The entomofauna complex.

For at least fourth years, a pionnier front of deforestation has spread into the Kwae Noi river valley (KAOJA-RERN S, 1992). The first agricultural activity following slash and burn cultivation was usually the maize-cotton relay cropping system which has gradually transformed the entomofauna complex composition. From a forested environment with balanced insect populations, the practices of monoculture and the systematic use of increasing quantitis of insecticides increased the proportion of several key pests, causing serious damages to the cotton crop such as aphids, jassids and **Helicoverpa armigera** ("American" bollworm).

Currently, the insect pest distribution in the studied zone is not homogeneous, their respective level of pressure depending mainly on the distance to a forested area. Insect pressure is also changing each year following a population cycle linked to bio-climatic conditions. In 1991, attacks of *Helicoverpa armigera* were limited when compared with the ones observed during 1986, when farmers could barely harvest less than 50% of the average seed-cotton production for the area (half of the usual 1000 kg/ha yield = 180 kg/rai). Thus, a pluri-annual experimentation has been set up at three sites in Kanjanaburi province to assess the evolution of the entomofauna complex as well as the changes in its composition.

3.1.1.2. Climatic conditions.

The pattern of rainfall distribution along the year and for several years is one of the main criteria taken into account by cotton growers to chose the sowing date. Their decision making process is based on information presented in table 2.

	ADVANTAGES	CONSTRAINTS
Early sowing in June	Total rainfall along the crop cycle is maximized (good yield potentialities).	.Long duration of intercrop in maize delays cotton growth. .High risk of rainfall at harvest time.
Late sowing End of july – August	Low probability of rainfall during harvest period	.suceptible to bollworm attacks because of the small bool size at the infestation period.

Table 2 : Information taken into account by farmers when choosing cotton sowing date in Tambon Tha Sao of Sai Yok District, Kanjanaburi Province.

The frequential climatic analysis (see figure 1) presents the probability of rainfall for each decade of the last 12 years. The rainfall pattern observed in 1991 is surimposed on this frequential analysis which displays clearly its characteristics (heavy rain in August, early end of rainy season etc...). Farmers who decided to sow in the third decade of June took the risk of a rain on opened bolls (the probability was 50% for the first decade of November and 25% for the second decade) but the rainy season ended of November and 25% for the second decade) but the rainy season ended early this year (third decade of October) and so they got the highest growth potentialities with a total of 960 mm of rain during the whole crop cycle (compared to cotton fields sown in early August which received only 720 mm of rain).

This example shows how farmer knowledge and empirical experience of local environmental conditions leads to the choice of a suitable cropping calendar taking some risk (sowing in June) or trying to minimize it (sowing in August).

3.1.2. The regional socio-economic environment

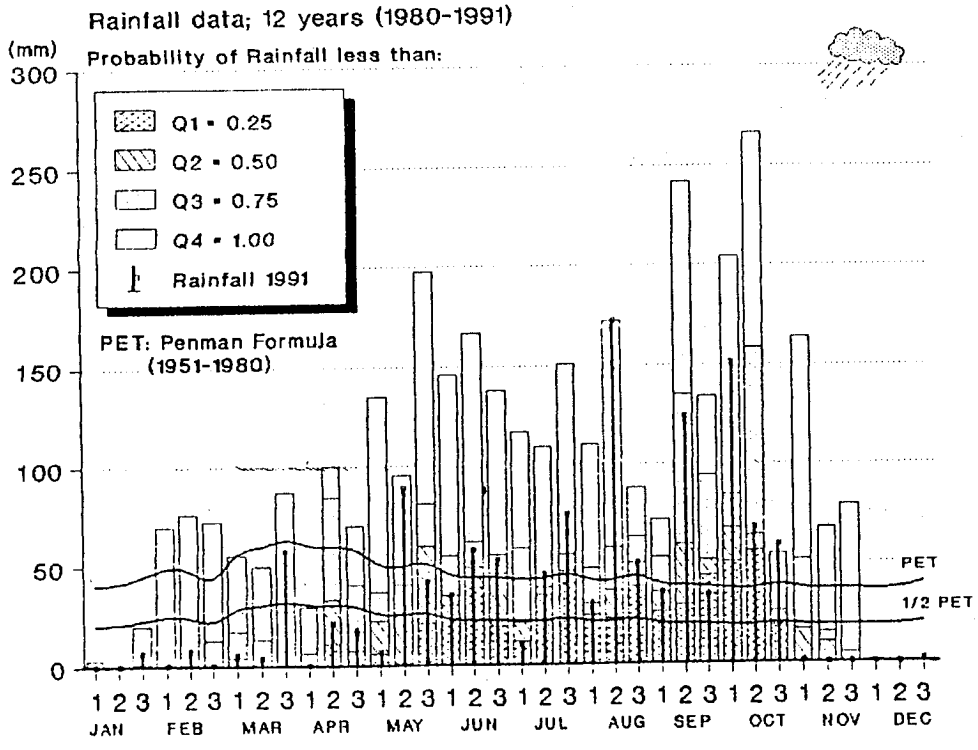
The recent evolution of crop protection practices is marked by an increasing diversity of practices which can be partly explained by a more and more diversified range of insecticides proposed to farmers without any adapted regional technical references.

This trend can also be explained by a limited, and very unequal, improvement of farmer technicity and an increasing awareness concerning the necessity to rationalize such practices.

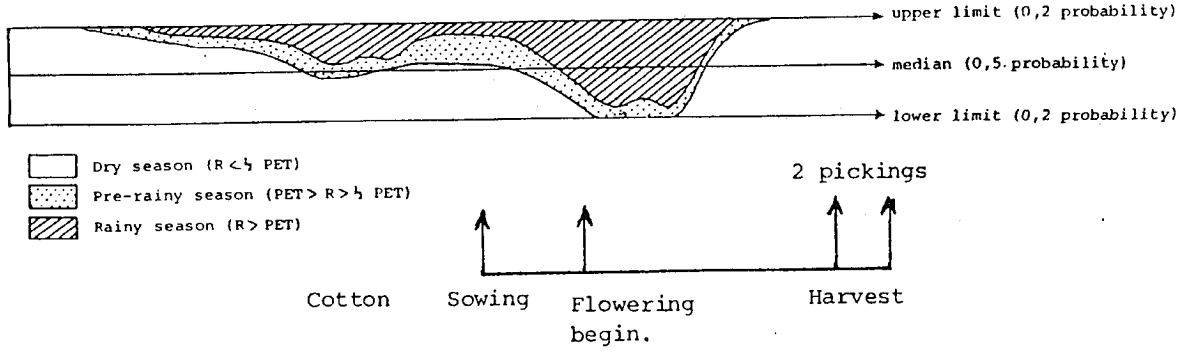
However, most of the farmers are technically adviced by local village middlemen, the "Taokaes", who are local relays of agro-chemical companies and gineries and have a wide spectrum of personnal influence on growers (apart from their technical "advice", they also provide them with commercial, financial and even sometimes social security services). They can control the production process thanks to the financial dependence they manage to establish with small farmers having no cash flow for input supplies and production marketing.

Figure 1. Agro-climatic data in Tambon Tha Sao, Sai Yok District of Kanjanaburi Province.

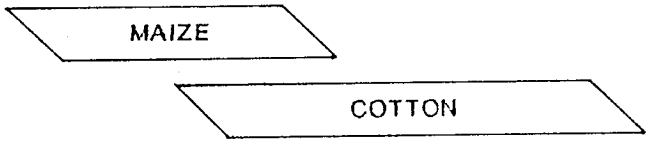
FREQUENTIAL CLIMATIC ANALYSIS:



CLIMATIC SEASONS:



CROPPING CALENDAR:
(Maize-Cotton cropping system)



Regarding social aspects of the local environment, one remarks a category of highly dependent growers, managing the most important part of the cotton planted area in the region. They are illegal migrants from Burma, illiterates in Thai for most of them, who are employed by "taokaes" providing them with a piece of land, all inputs for maize-cotton production but also all the family consumption needs including medical assistance. At harvest time, the "taokaes" pay them seed-cotton production after deducting their own price of inputs and other services as well as interests. Farmers are pushed into a spiral of increasing input consumption, especially for the pest control and fertilization, which gradually reduce the competitiveness of cotton production. Now, most of them try to diversify their productions by reducing the cotton planted area.

In such socio-economic conditions, the official DOAE extension service does not seem to have much influence, in the field of cotton crop protection practices, especially when compared with agro-chemical companies, ginneries and their local representatives at the village level. Such an example demonstrates clearly how important it is to carry out an in-depth study of the factoors determining farmers technical choices at the APS level.

3.2. THE POTENTIALITIES AND CONSTRAINTS OF THE AGRICULTURAL PRODUCTION SYSTEM FUNCTIONINF FOR MAIZE-COTTON CROPPING SYSTEM.

3.2.1. Rationality of maize-cotton cropping system in the local environment

Table 3 presents the main features of the surveyed APS in 1991.

A.P.S	A	B	C	D	E	F	G	H	I
Total farmed area	3	2,3	4,8	13	4,6	3,5	2,7	9,6	2
Owned land (ha)	2,3	1,1	4,8		4,6				
Hired land	0,8			3,4		3,5	2,7	4	2
Maize area (ha)	2,7	0,8	3,7	4	4,6	3,5	2,7	7,2	1,7
Cotton area	1,8	0,4	3,4	2,9	4,6	3,5	1,6	9,6	2
Orchard		0,8	1	4,6	0,5		0,2	5,6	
Vegetable		0,3	0,3	2,4	0,3				
Animals (number)			3 cows		8 goats				
Family laborforce	1	2	2	2	3	2	2	1	2
Hired laborforce								2	

Table 3. Characteristics of the APS in Tambon Tha Sao of Sai Yok District, Kanjanaburi Province, surveyed in 1991.

Farmers F, H and I are Mon ethnic migrant from Burma who hire their farm area from local "taokaes" and have no other choice than maize–cotton productions. Part of these annual crops are intercropped in young orchards in which the farmer does not pay a rental fee but just maintain the plot (weeding, fertilization, crop protection, etc...) for the absenteist land owner.

For other APS, the feasability of alternatives to maize–cotton depend on their available cash flow and thus on their degree of dependence on the local "taokae". Access to bank short term credit allows them to buy part of the field crops inputs every year. If their land tenure is secured (B, C, D and E), they can also diversify their production by planting perennial crops, mainly fruit trees and bamboos (for spear production).

But the choice of maize–cotton relay cropping system, which decreases the potential yield of both crops correspond also to a global strategy that can be characterized as follows:

(i) risk minimization by dividing the risk of failure on two crops and limiting production costs for cotton (no land preparation, reduced weeding),

(ii) regular cash flow distribution all along the year with two harvests (August and December),

(iii) smooth management of a limited laborforce (maize harvest is done at the same time than cotton weeding and mulching by maize straw).

3.2.2. A typology of cotton producting Agricultural Production Systems

Several quantitative criteria have been selected to identify a limited number of APS types based on their main strategies, potentialities and constraints for cotton production (see table 4).

TYPE OF APS	I	II	III
LAND			
% Owned land	75 – 100	0 – 100	0
% Annual crops	95 – 100	65 – 90	100
LABORFORCE (/ha)			
Number of work, day / cotton cycle	40 – 90	50 – 75	90 – 150
CAPITAL			
Input (equivalent in kg seed cotton/ha)	80 – 200	200 – 320	320 – 800
Fixed costs (kg seed cotton/ha)	5 – 12	12 – 16	16 – 40
% Input/Gross Product	40 – 50	10 – 30	40 – 70
TECHNIQUES			
Insecticed (quantity: l./cycle/ha)	2 – 10	1 – 5	12 – 23
Spraying (number of applications)	3 – 7	4 – 7	8 – 17
Weed control (number)	0 – 1	2 – 5	2 – 4
Yield (kg/ha)	400 – 500	700 – 800	900 –1200

Table 4 Typology of Agricultural Production Systems growing cotton in Tambon Tha Sao of Sai Yok District, Kanjanaburi Province.

Land tenure is appearing as a key indicator of the APS type because it implies the feasability or not of alternative crop system to maize–cotton.

For type III APS, there is no other choice than these annual crops which are selected by the "taokae" himself (also a product marketing agent for these productions). This latter, by managing the input (he choses varieties, fertilizers, insecticide active ingredients, rate and frequency of applications, etc...), he is able to control all the steps of the itinerary of techniques without taking part in its practical implementation. He receives the technical advice mainly from agro–chemical companies who supply him with products for sale and favour high consumption.

Thus these farmers use a lot of inputs (equivalent to 320 to 800 kg seed-cotton/ha), without technicity, taking very high risks for their health and their environment by spraying very toxic insecticides, etc... but they obtained the best yields! However, the "taokaes" objective is to maximize both input supplies and crop production per land unit. In such conditions, cost of the inputs can reach up to 70% of the gross product, and therefore type III farmers have a lower than type II APS, even with a better yield!

Type II is characterized by a diversification of agricultural production thanks to a better cash flow availability and access to the bank short term loans. The means of production (small equipment, input, labor force, etc...) are distributed among different crops and their management is benefiting from better technical skills (choice of the active ingredients adapted to each insect, spraying according to an economic treshold, etc...) maintening this cropping system competitive (%inputs/gross product = 10 to 30% only). Now, the trend is toward a reduction of field crops which are replace by orchards requiring less labor and inputs.

Type I APS are small independent family holding who have an objective of earning a limited but regular amount of cash income without peak of labor demand because of the old age fo most of the family labor or off-farm (low number of insecticide spraying) and laborforce (low weed control) in order to secure a limited margin at low financial risk.

3. THE EFFECT AT PLOT LEVEL OF FARMER PRACTICES ON PLANT GROWTH AND YIELD DIFFERENTIATION AMONG APS.

Each type of strategy performed by the farmers when managing their maize-cotton cropping system is leading to a different itinerary of techniques, For crop protection practices, the main factors of variation are: the type of active ingredients, the dose, the volume sprayed and the frequency of application.

		A.P.S / TYPE								
GROUP OF INSECTICIDE	unit	A I	E I	B II	C II	D II	F III	G III	H III	I III
CARBAMATE	g a.i.	70						208	84	
	l.	0,4						1	0,4	
ORGANOCHLORINE	g a.i.	218	1652		53	334	1969	2160	771	937
	l.	0,6	4,7		0,2	1	5,6	6	4,2	2,7
ORGANOPHOSPHORUS	g a.i.	326	888	915	390	1115	4538	1305	6637	2179
	l.	0,7	1,5	1,7	0,8	2,4	8	3,3	11,7	5,7
PYRETHROID	g a.i.	3			6	22		157	455	208
	l.	0,03			0,2	0,4		1,2	3,9	3,3
TRIAZAPENTADIENE	g a.i.	75	879	80		167	1125	900	334	
	l.	0,4	4,4	0,4		0,8	5,6	4,5	1,7	
TOTAL	g a.i.	692	3419	995	449	1638	7632	4730	8281	3324
	l.	2,1	10,6	2,1	1,2	4,6	19,2	16	21,9	11,7
INSECTICIDE SPRAYING	time	3	7	4	4	7	17	17	11	8

Table 5. Differentiation of crop protection strategies among cotton growers surveyed in 1991.

APS "A" uses obviously lower doses than the technical recommendations and sprays only three times the same mixture of all the active ingredients without previous observation of the entomofauna.

Farmer "C" sprays the right doses of product adapted to the type of insect identified. He sprays especially the plot areas where the insect pressure is the highest in order to save inputs.

Farmer "H" follows a weekly spraying programme by mixing 2 or 3 active ingredients and foliar fertilizer at each application.

The effect of these strategies on insect population, followed up by weekly scouting is presented figure 2 for jassids.

Numerous jassids early in the cycle are well controled by APS "C" up to the 90th day. Then, the biomass of the canopy being important, jassid attacks do not affect the vegetative growth and thus the yield potential.

Farmer "H" treatment leads to the potential growth curve in the absence of sucking insect infestation (see figure 3).

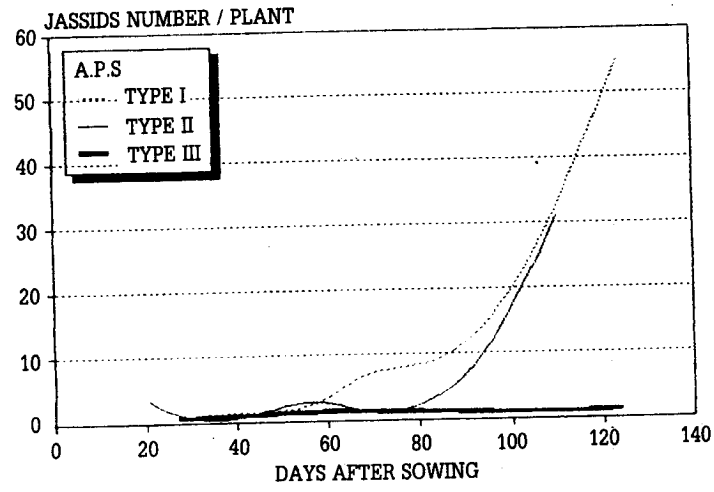


Figure 2. Evolution of jassid infestation on farmers cotton field under three crop protection strategies.

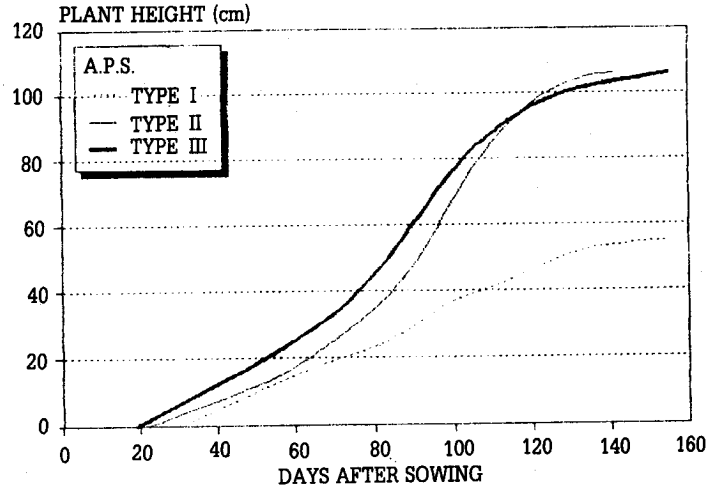


Figure 3. Cotton vegetative growth under three crop protection strategies: on-farm monitored plots.

These farmers practices can be assessed by using the results of the on-farm experiments carried out by DORAS Project in the same area in 1991. They consisted in three levels of crop protection comparable to farmers "A","C" and "H" strategies.

One of the main results concerns the effect of early sucking insect attacks which decrease the vegetative growth of the cotton plant and then lower the yield. It is the case for APS "A" whose cotton plants were 50 cm smaller than two other plots, reducing significantly the number of fruiting sites and then the number of bolls per plant.

"H" got the best yield but at what price? The table 6 shows the low economic efficiency of "H" strategy in 1991 environmental conditions.

FARMER	"A"	"C"	"H"
YIELD (kg/ha)	440	920	1200
NET INCOME (in kg of seed cotton)	170	680	250
% NET INCOME / GROSS PRODUCT	39	74	21

Table 6. Comparison between cotton grower incomes using three different strategies for management of crop protection inputs.

CONCLUSION

Finally, this example underlines that a yield optimization should be prefered on a yield maximization by a better rationality of input, especially insecticide, management.

Improvement of the sustainability and the competitiveness of cotton production for these three APS types should be based on different approaches. It is also important to keep in mind that very often, the solutions have to be found at another level than the one at which the problem has been identified. For the "type III" APS, the lack of farmer technicity in compensated by some input wastes which could be avoided. In fact, this situation is controled by "taokaes" who manage their personal economic interest before the one of farmers under their dependence.

Extension activites should take into account this type of social relation and conflicting interest between farmers and middlemen to imporve input management problems at the plot level, given the potentialities and constraints of their APS.

For types I and II APS, one can propose "environmental friendly" crop protection techniques:

(i) management of sucking insect pests by using hairy varieties for jassid tolerance, seed treatment by systemic insecticides having narrow spectrum and low toxicity and gradually switch to low toxicity insecticide active ingredients for delayed aerial sprayings.

(ii) actions at the regional and national economic environment for the availability of low toxicity insecticides active ingredients only, improvement of their presentation (label, antidote).

REFERENCES

CROZAT Y. and CHITAPONG P., 1988. *The On-Farm Agronomical Survey: A Tool for Grading Limiting Factors of a Crop and Designing New Technologies.* In Farming Systems Research and Development in Thailand, Illustrated Methodological Considerations and Recent Advances. Prince of Songkhla University 1988, pp 87-110.

KAOJARERN S., TREBUIL G., TRIMONGKOLKUL P. and NGERNPRASERTSRI N., 1992. *Agro-Ecological Zonation and Recent Agroecosystem Transformations in Kanjanaburi Province: Hypotheses for Improving Farming Systems Sustainability.* Proceeding of the 9th Thailand Farming System Seminar, Phuket.

NARITOON C., TRIMONGKOLKUL P., NGERNPRASERTSRI N., PANTOOMNAVIN N. and TREBUIL G., 1992. *Farming System Sustainability and Capital Accumulation: an Interpretation of Farmer Differentiation in Saiyok District of Kanjanaburi Province.* Proceedings of the 9th Thailand Farming System Seminar, Phuket.

SEBILLOTTE M., 1978. *Itinéraires Techniques et Evolution de la Pensée Agronomique.* Compte-rendu de l'Académie d'Agriculture de France. 64, 906-914.

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