Thai cotton growers still far away from IPM: contribution of systems approach to a better understanding of farmers' practices

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ABSTRACT

On-farm surveys have been performed for three cropping seasons since 1991 in two cotton growing areas in Thailand. A systems approach focused on farmers' technical choices in relation to characteristics of the bio-physical and socio-economic environments as well as the differentiated functioning of their production systems. On-farm experiments aiming at assessing the impact of different pest management practices on the cotton crop have been carried out in the same areas.

Intensive cultivation practices have brought about fundamental transformations of the ecosystems (e.g. evolution of the entomofauna, and insect resistance) as well as the farming systems (high input use, dependence on agrochemicals and lint processing industries, spiralling production costs, etc.) all of which has led to a steady reduction in cotton production during the last few years. One key factor identified as a major constraint for cotton production is the inability of farmers to control pests through economically and environmentally sustainable cultivation practices. Although most cotton growers are aware of the 'environmentally friendly' techniques promoted by agricultural extension agencies, they are not able to implement them because of constraints imposed by their socio-economic environment. Thus, Integrated Pest Management (IPM) propositions should avoid any standardized set of pest management techniques, but should promote an approach utilizing agro-ecological principles and translating them into a socio-economic framework respecting farmers objectives.

Introduction

Cotton growing in Thailand is facing a crisis, the origins of which have been previously described (Grimble, 1971; Collins, 1986; Evenson, 1987a; Jan-orn, 1989; Castella, 1993). Growers are taken into a vicious cycle of increasing production costs, due to the heavy use of chemical insecticides. A historical analysis of cotton pest management reveals the same recurring patterns as in other regions in the world, characterized by a series of successional phases beginning with a subsistence phase of low input, low yielding cotton production and progressing toward a pesticide-dependent phase (Falcon and Smith, 1973; Bottrell and Adkisson, 1977). The six identified stages in cotton production are:

1. Subsistence phase
2. Ecologically oriented pest control
3. Exploitation phase
4. Crisis phase
5. Disaster phase, and
6. Integrated control phase.

Thailand has now passed through the first five successive phases for the second time in its cotton growing history but has never really reached the sixth (Fig. 1).

However, numerous studies have been carried out which addressed problems of pesticide misuse and successfully tested alternative strategies. These latter techniques (which

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G.A. Constable and N.W. Forrester (Eds), CSIRO, Melbourne, pp. 411–418.

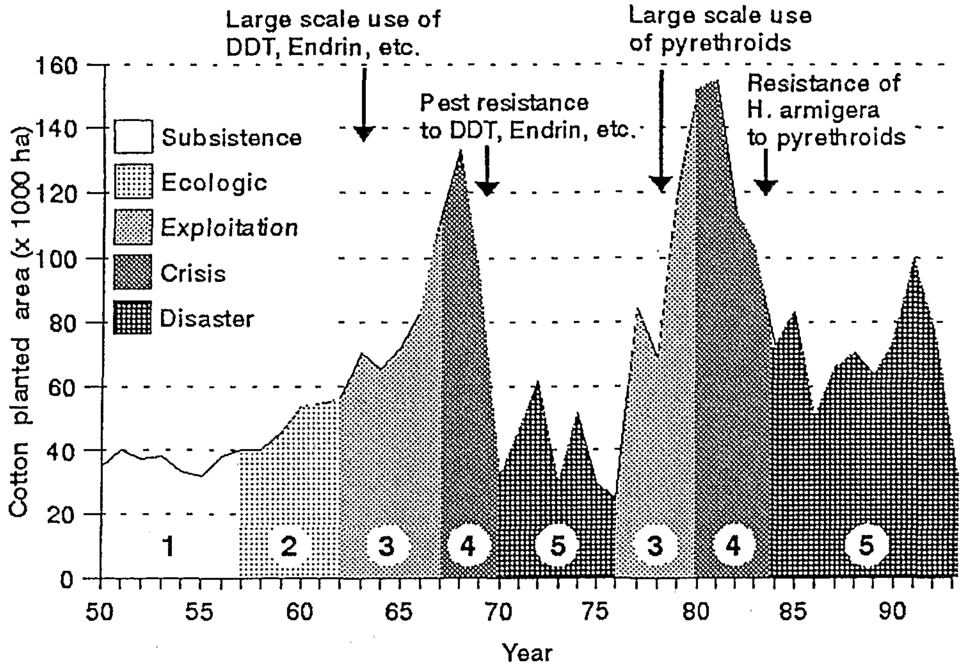


Fig. 1. History of the area planted to cotton in Thailand and successive historical phases in cotton production (1950–1992).

Source: Office of Agricultural Economics, Ministry of Agriculture and Cooperatives, Thailand.

include varietal non preference for pests, cultivation practices, biological control, management of beneficial insects, etc.) are usually referred to as Integrated Pest Management (IPM) techniques (Stern *et al.*, 1959; Oudejans, 1991). They consist of a set of pest control practices which have been shown to be economically and environmentally sustainable in testing stations and through on-farm experiment and demonstration plots (Deema *et al.*, 1974; Evenson, 1987b; Gips, 1987). They are present now in all the academic discourses, as they were in the early seventies, before being wiped out by the emergence of synthetic pyrethroid insecticides. However, they have not yet been implemented by Thai farmers though they are aware of them through extension workers.

Farmers' behaviour toward risk is often considered as a constraint for IPM implementation by researchers and extension workers (Reddy *et al.*, 1990; Cauquil and Vaissayre, 1994). Thus, many IPM programs fail to be adopted by farmers because they focus on insect control and plant damage reduction before paying attention to the objectives and needs of their potential users. A better understanding of the rationality of farmers' pest management practices is a prerequisite for the construction of IPM programs tailored to their own circumstances (Kenmore *et al.*, 1985). The proposed systems approach emphasizes the role of farmers as central actors in the process toward IPM.

Methods

The holistic diagnosis integrates three complementary levels of analysis of farmers' technical, ecological and socio-economic environments which are assumed to influence their decision making process. The complete study was carried out in two cotton producing areas of Thailand from 1991 to 1994 by an interdisciplinary team of researchers.

At the regional level

Two rainfed cotton-producing areas at the periphery of the Central Plain of Thailand were selected because they were assumed to represent two successive stages in the artificialization process of the ecological environment. The Kanjanaburi area (Saiyok district) is a recently opened agricultural area, characterized by poor yielding cotton production when compared with Lopburi province (Chaibadan district) where four decades of agricultural history have led to production intensification through mechanization and high pesticide use.

The main features of 'regional agricultural environment' have been studied through articulated *time* and *spatial* zoning tools.

- A frequential climatic analysis along with a seasonal pest profile (i.e. pest population distribution, Teng and Savary, 1992; Castella, 1993) and monitoring of pest resistance to insecticides (Caron, 1992) provided the frame of experience, that farmers take into account when making decision.
- An agricultural historical profile performed through interviews with key informants (farmers, officials, monks, etc.) links agro-technical evolutions to socio-economic changes, especially those regarding land tenure, labour market, access to capital, relations among farmers and with other economic agents, and modalities of government interventions (Trébuil *et al.*, 1994).

Farming systems functioning and classification

Three successive surveys were performed. The first aimed at describing the main characteristics of the regional farming systems through a short questionnaire. Two samples of 823 and 538 farms were chosen in Lopburi and Kanjanaburi areas, respectively, using official agricultural statistics. Then interviews including farmer plot visits were carried out using a guideline for data gathering and indepth analysis of 30 farming systems per studied area. Sampling tended to maximize diversity of the observed cotton-based cropping systems[1] rather than looking for a representative sample of regional situations. The objective of this second survey was to identify several types of farm having similar management criteria, strategic orientations and limiting factors, for which it was likely that the same recommendations would be suitable (Trébuil and Dufumier, 1990). The following stage consisted of verifying whether such a typology, based on a small sample, could effectively represent the diversity of regional farming systems. Thus, the two initial large samples were surveyed again, using the same criteria that had been shown to be relevant, to discriminate the different categories of farming systems, in order to assess the frequency of each farm type in the whole population.

Plot level analysis

An agronomic diagnosis consisted of monitoring farmers' cultivation practices through weekly interviews (technical choices, input and labour management, economic data, etc.) associated with direct observations on cotton crop (growth, insect damage, fruiting organs mapping, etc.) and its environment (soil structure, rainfall, weed infestation, insect scouting etc.).

A network of explanatory experiments consisting of four levels of plant protection (i.e. no protection, seed treatment against sucking insects for early vegetative protection only, spraying according to an economic threshold for each pest, weekly insecticide application) for plants sown at three consecutive dates was established in order to monitor pest–crop interaction all along the cropping cycle and assess the seasonal variability.

Finally, relevant propositions of innovation toward IPM have been proposed for each type of cotton-based cropping system according to their characteristics. This system's approach is closely articulated with on-station experiments through identification of research topics well adapted to the reality of cotton production in the studied areas.

Results and discussion

This paper will focus on current farmers' practices in the domain of cotton pest management and relate the observed variability to the functioning of the differentiated farming systems.

A typology of cotton growing farming systems in Kanjanaburi and Lopburi provinces

Five categories of farming systems have been identified in relation to their potentialities and constraints for cotton production (Table 1). Simple indicators characterizing each type of farming system are able to easily classify into one of its categories any farm taken in the domain of validity of the typology. Their ability to discriminate different types of pest management strategies and understand their origin has been established through agronomic monitoring on a limited sample of farming systems.

Type A

Type A are small farming systems characterized by a very low availability of capital. Despite a steady increase of production costs, which reduces their profit margin and increases the risk of economic failure, they keep on producing cotton because they have no alternative for a more profitable production per land unit in the local agro-ecological conditions. Their cultivation practices aim at minimizing risk (no profit is preferred to a negative result) by using very low input (no fertilizer, decisions on pest control based on intervention threshold, low doses of poor quality insecticide formulations). They bet on a 'good cotton season' (low insect infestation, regular distribution of rainfall along crop cycle) to make some profit and in the worst case to avoid losing the invested capital. This cropping system usually associates cotton with less risky production, such as maize or sorghum, in order to secure a minimal family income. A complementary income is commonly sought off-farm as soon as the rainy season ends.

Type B

Type B farmers, also managing small farming systems, rely on cotton production to maximize their income on a limited cultivated area. A weekly application of high quality but expensive insecticide cocktail (formulations from multinational companies) aim to avoid any risk of unexpected pest outbreak. Such a mono-cropping pattern presents high economic risks because of the important capital invested, especially for pest control (around 80% of total input cost). All the efforts of one season can be wiped out by an insect outbreak due to this type of pest management paying no respect to the biological balance between pests and their predators and parasites. It is not uncommon to see such farmers obliged to hand over their land to middlemen, after a 'bad' season, to reimburse their loan.

Type C

Type C is predominant in the Kanjanaburi area. It includes illegal Mon migrants from Burma who are economically dependent on local merchants. They are obliged to practice

[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 (Sebillotte, 1990).

Table 1. Main characteristics of cotton-based farming systems in the two studied areas and their relative frequency.

Type of farming systems	A	B	C	D	E
Frequency (% of surveyed farms)					
in Kanjanaburi area (sample = 538 farms)	6.2	5.0	74.5	14.3	0
in Lopburi area (sample = 823)	11.4	24.9	0	49.9	13.8
Characteristics of the farming systems					
Total cultivated area per family worker (ha)	3–5	1–2	5–10	3–5	>8
% cotton area/total area	40– 60%	>70%	95–100%	5–20%	<10%
Labour (F, Family, H, Hired labour)	F only	F > H	F > H	F > H	H > F
Equipment for insecticide application	Knapsack sprayer	Motor sprayer	Motor sprayer small tractor	Motor sprayer tractor	Pump on big
Capital (Baht /ha)					
Insecticide costs	500–1000	4000–7000	1000–4000	2000–5000	4000–10000
% insecticide cost/total input cost	30–50%	60–80%	40–70%	50–70%	60–80%
Socio-economic objectives of cotton production	minimum risk, spare time for off-farm activities	maximum net income per land unit	economic dependence on middlemen	maximum family income through agricultural activity only	maximum rate of profit
Management indicators					
Sowing date	early June	early June	early July	end June	early July
Density (x 1000 plants/ha)	10–15	18–25	21–23	18–25	12–16
Number of pesticide sprays	3–7	10–15	10–20	8–12	8–12
Total amount of insecticide (L/ha)	2–5	12–20	10–30	7–15	12–20
Yield (kg seed cotton/ha)	150–800	1500–3000	1000–1500	1500– 2500	1000–2000

* US$1 = 25 Bahts

maize–cotton relay cropping and to use inputs provided with high credit rates (3–5% per month) by their 'protector'. These farmers use high quantities of pesticides without knowledge, taking high risks with their health. They receive technical advice from the middlemen, whose objective is to maximize both input supplies and yield because they get a comfortable margin on both of them. Observed pest management practices are obviously neither economically nor environmentally sustainable but can be explained by a social relationship of dependence.

Type D

Type D is characterized by a diversification of agricultural production, thanks to a better cash flow availability and access to short term bank loans. Pest management benefits from better technical skills (choice of active ingredients adapted to each pest, spraying programme based on a 10-day frequency which can be increased if insect populations reach the economic threshold), keeping the cotton crop competitive. However, cotton accounts for less than 20% of the farmed area and resort to hired labour is frequent in order to allow a better management of the limited family labour force.

Type E

Type E farming systems benefit from higher means of production (land, capital, equipment, etc.) than previous groups. They usually associate intensive crops (cotton, soybean, etc.) with extensive production (maize, sorghum, etc.). Cotton plant density is adapted to mechanization: an interrow of 1.8 m enables tractors to perform weeding during the vegetative stage of the crop and allows use of a pump for insecticide treatment.

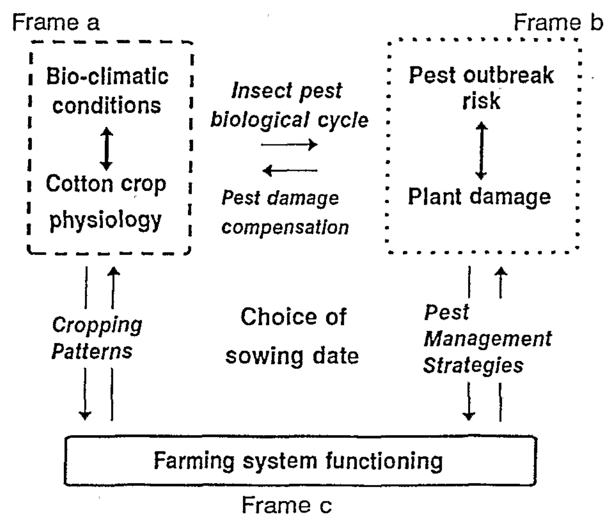


Fig. 2. Model of interaction between the three frames of constraints taken into account by cotton growers for the choice of a sowing date.

Such a typology, based on farmers' goals by taking into account constraints and potentialities of the farming systems they have to manage, helps to model farmers' decision making processes.

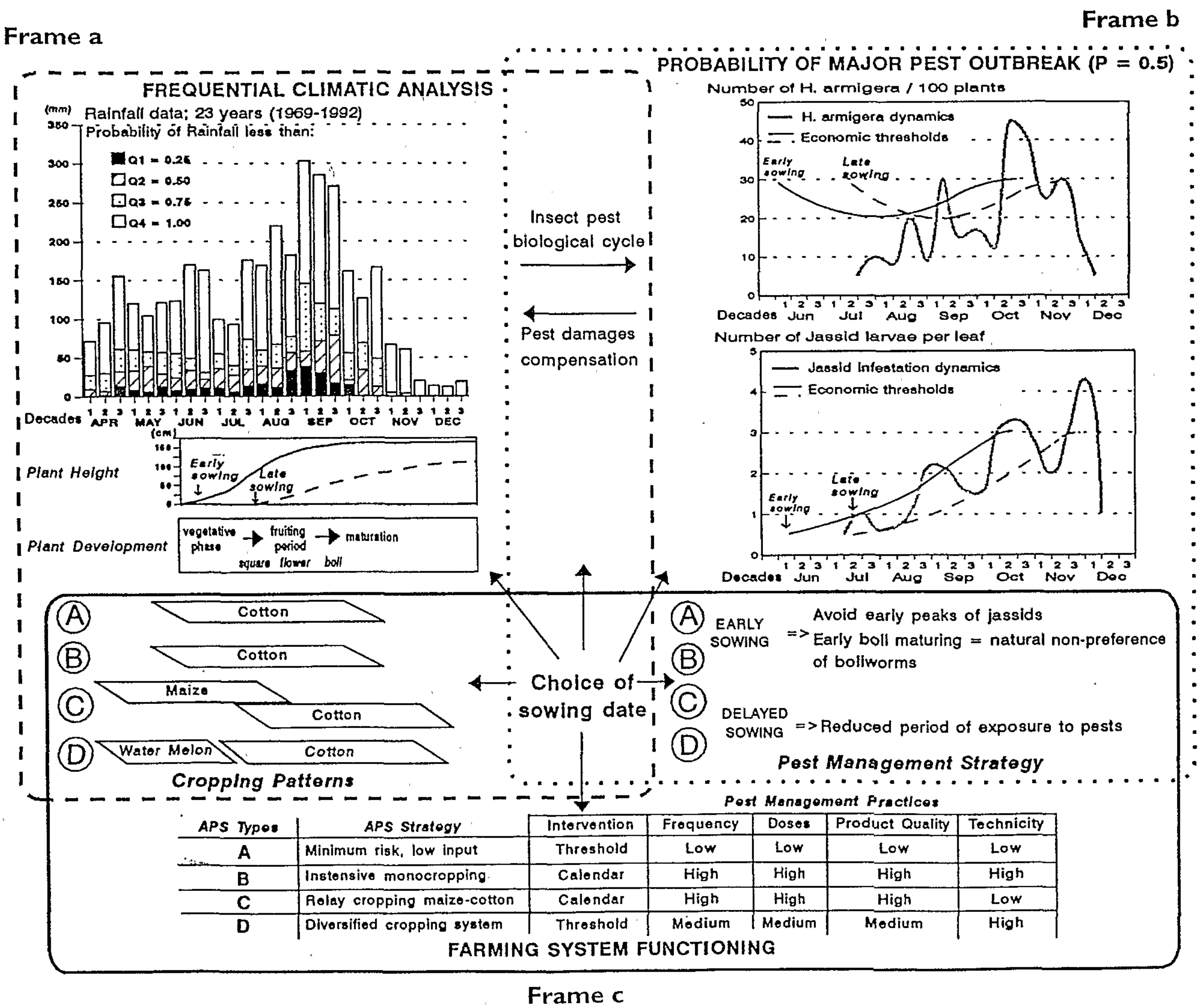
Impact of farming systems functioning on strategic and tactical decision making for cotton pest management: choice of sowing date

The choice of the sowing date is an important pest control measure implemented by cotton growers. According to on-farm surveys, this decision integrates three complementary levels of perception: the bio-physical and ecological environments as well as constraints imposed by the farming system's functioning.

Although agro-ecological events (rainfall, pest outbreaks, insect resistance, etc.) and agricultural facts (farmers' practices and words) are the only source of information for on-farm research, they do not allow, taken separately, to assess the coherence of a set of technical choices. The decision-making process pays more attention to the relationship between components of a system than to each of them taken separately. Thus, the choice of a sowing date results from interactions between the three identified frames of constraints (Fig. 2). A holistic approach allows to appraise the relevance of a practice by overlapping those frames two by two (characterization of pest–crop interactions, pest management strategies, cropping patterns) and then integrating all of them.

Agro-ecological frame of constraints: plant–climate and plant–pest interactions

Farmers reason in terms of risk when considering all the exterior events interfering with the system they are managing. The logic of their choices may be assessed through a frequential climatic analysis underlining the relative advantages and constraints of each alternative (Frame *a* in Fig. 3). An early



APS Types	APS Strategy	Intervention	Frequency	Doses	Product Quality	Technicity
A	Minimum risk, low input	Threshold	Low	Low	Low	Low
B	Instensive monocropping	Calendar	High	High	High	High
C	Relay cropping maize-cotton	Calendar	High	High	High	Low
D	Diversified cropping system	Threshold	Medium	Medium	Medium	High

Fig. 3. Schematic representation of farmers decision making process for the choice of cotton sowing date.

sowing maximizes plant growth potential through higher availability of efficient rainfall through the crop cycle. But it also implies a higher probability of drought at emergence period, which may not allow an even establishment of seedlings (complete re-sowings are not scarce), and an increasing risk of a first seed-cotton picking under rainy conditions. Late sowing presents the opposite potentialities and constraints toward rainfall patterns.

Compilation of experimental data collected over three years at five locations has resulted in a curve of insect population distribution for two major pests (*Helicoverpa armigera* and *Amrasca devastans*). It represents the median level of infestation, which has a 0.5 probability of occurrence through the cropping season. It is assumed that an event which can take place one year in two is seen by farmers as highly risky. Thus, the soundness of farmers' decisions according to probability of pest outbreak, has been assessed by superimposing an economic threshold curve (indexed on plant growth: ratios number of fruiting sites per bollworm or number of leaves per jassid nymph) on probability distribution of insect populations (Frame *b* in Fig. 3).

An early sowing allows risk reduction of high jassid pressure when the plant is the most sensitive (i.e. young seedlings) and avoids non-recoverable bollworm damage. Early boll maturing provides a natural defense (non-preference of mature bolls) against bollworm attacks at the end of the season.

Integrating agro-ecological constraints into farmers' socio-economic frameworks

Assessment of farmers' practices through their effects on the plant population in a given bio-physical context does not by itself allow an understanding of a global pest management strategy. Indeed, the same practice can result from two different logics. A and B farming systems practice early sowing for the same agro-ecological reasons, but the latter's objective is to maximize the number of harvestable bolls per area unit through high input use while A intends to secure a minimum yield with low financial risk and labour requirement. In the same way, Type C farmers perform pest control techniques similar to those of Type B because they have no alternative choice. Their whole insect management program is directed by the local merchant, on whom they rely for input supply.

Farmers' rationale for a given practice is linked to perception of their natural environment and its impact on the cotton plant through pest injuries and losses (Frame *c* in Fig. 3). Each success or failure in a pest management technique is integrated in a frame of experience which leads to a 'state of the art' in cotton protection practised by each farmer to fit to his own circumstances. Thus, any recommendation should be consistent with the logic of each pest management strategy underlying a practice.

Finally, a pest management program is made from a succession of operations which are easy to observe and describe. But taken apart from their context, practices often look inappropriate for solving pest problems in the long run. Farmers are then seen as natural resource spoilers or irresponsible managers endangering the sustainability of their own farming systems. In this regard, most Thai cotton growers are obviously still far away from IPM techniques (Table 1).

However, they usually have good reasons to implement such practices, the coherence of which appears when considering their complete frame of decision making (Fig. 3).

From farmers' current practices to IPM techniques

Prerequisites for farmers' adoption of innovations

Recommendations should fulfil the following requirements in order to have a chance to be adopted by farmers.

1. Farmers are more interested in benefit optimization than yield maximization. Thus, an on-farm research programme intending to improve productivity of agricultural production systems should include quantitative and qualitative improvement of the production as well as reduction of production costs. For example, re-introduction of hairy leaf cotton varieties in Thailand as a natural non-preference factor for jassids should reduce the production costs via decreasing cost of sucking insect protection (for farmers using an intervention threshold). However, other characteristics of the cultivar (yield potential, lint quality, sensitivity to *H. armigera*, etc.) should be at least at the same level as the local one to be adopted by farmers.
2. Reduction of production costs is a key factor for many farmers whose practices often reflect attempts to increase the stability of production and to reduce the risks of failure. Before proposing a technology that relies on a uniform sowing date, for instance, on-farm researchers should take account of farmers' rationale for staggered planting dates.
3. Another factor in farmers' decision making, related to risk aversion, is the fact that farmers tend to change their practices in a gradual, stepwise manner. They compare their own practices with alternatives which are cautiously tested before adoption. Thus, any proposition for a set of recommendations should allow farmers to make changes one step at a time, because they will show reluctance in adopting a complete technological package (CIMMYT, 1988).

Conditions for a sustainable pest management programme

One concept which emerged as a solution at each crisis period of cotton pest management in Thailand is that of Integrated Pest Management. However, lessons should be learnt from past experiences of IPM programme failures in Thailand (Deema *et al.*, 1974) due to a lack of concern with farmers' ability to effectively implement a complex set of pest management techniques.

Table 2. IPM techniques tested by the DORAS project in Thailand and their chance: high (H), medium (M) or low (L), of adoption by farmers in the present context of cotton production

IPM Technique		Potentialities	Constraints	A	B	C	D	E
Cultural practice	Early sowing	- avoid early peaks of pest population - increased potential of production	- risk of rainfall at first picking time - increased time exposure to insects	H	H	M	L	
Varietal selection	Early maturing varieties	- reduce time of exposure to insects - well adapted to mechanization - late sowing date	- high sowing densities, low penetration of insecticides - low possibilities of compensation				M	H
	Hairy varieties	- hardy - natural tolerance to jassids - increased populations of whiteflies and thrips	- increased *H. armigera* oviposition	H	L	L	L	L
Pest control technique	Seed treatment	- early protection against sucking insects - protect beneficial insects - risk of increased populations of whiteflies and thrips due to a reduced competition with jassids	- expensive strategic choice since rainfall pattern is uncertain	L	H	M	H	H
	Biological control (Bt, NPV, etc.)	- alternative to chemical insecticides - selectivity, protection of beneficial insect, no environmental degradation - risk of insect resistance if misused	- expensive and not available through local merchants because of agro-chemical companies strategies - less convenient use	L	M	L	M	H
	Hand picking	- best way to eliminate big larvae instar - damage already done	- time consuming, limited to small areas	H	H	M	L	L
Spraying programs	Low dose/high frequency program	- reduced amount of chemicals, first step toward intervention on threshold (Cauquil and Vaissayre, 1994)	- insect scouting, - requires farmers' technical skills, training and monitoring from extension workers		H	H		
	Targeted staggered program	- narrow spectrum insecticides for targeted pests (Deguine *et al.*, 1993) - less damaging to beneficials - reduce number of treatments		M	L	H	H	
	Economic threshold	- economically and environmentally sustainable	H	L	L	M	M	

The setting-up of a sustainable pest management programme implies a gradual transformation of farmers' practices (i.e. introduction of seed treatment against jassid damages during the highly susceptible phase of vegetative growth sparing beneficial insects, Genay *et al.*, 1993). In the short term, it consists of tactical recommendations for farmers which are easy to follow, given the constraints of their farming systems and the requirements they impose on any innovation. Then, a gradual process toward an IPM programme should be proposed to each type of farm fitting their own original circumstances. Table 2 presents propositions for IPM techniques which are currently tested by the DORAS project through on-station and on-farm experiments as well as a preliminary assessment of their relative chance of adoption by each type of farming system. The lengthy process of diagnosis guides on-station work and helps extensionists to make the results available to farmers by pointing out the economic or institutional obstacles that have to be overcome.

Conclusions

Entering the sixth phase of cotton production history will not be an easy enterprise given: the critical stage which has already been reached in the environment degradation process (Trébuil, 1993); a government policy which supports the textile industry through raw cotton imports at low prices;

and alternative agricultural or non-agricultural activities which have emerged in recent years.

However, rapid solutions toward an improved sustainable pest management have to be found before an intolerable situation spreads to other production, especially orchards and vegetable crops.

> "The systems approach has shown its relevance to deal with the inter-related components of such fragile ecosystems where disasters have occurred because of non-holistic pest management practices in the past. IPM is not a technological package that farmers can adopt if they see their interest, but an approach utilizing agro-ecological principles and translating them into a socio-economic framework respecting farmers objectives" (Teng and Savary, 1992).

Recommendations targeted at the various types of farmer should receive good responses becauses the future users have been involved in the successive phases of their elaboration. In the same way, extension personnel and, more widely, all the actors of regional agricultural development should be involved in such research and development processes.

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