Farmers' knowledge, perceptions and practices in mango pest management in the Mekong Delta, Vietnam

(*Keywords:* farmers' knowledge, pests, pesticides, integrated pest management, mango, information transfer)

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Abstract. A survey of mango farmers' knowledge, perceptions and practices in pest management was conducted during the dry season of 1998 in the Mekong Delta, Vietnam. Identification and control of pests was often based on damage symptoms, rather than on recording of causal agents. Damage caused by the seed-borer *Deanolis albizonalis* (Hampson) was often wrongly attributed to the fruit flies *Bactrocera dorsalis* Hendel. Nearly all farmers applied calendar sprays of insecticides (97%) and fungicides (79%) from pre-flowering until harvest, with on average 13.4 and 11.6 applications per year, respectively. Pyrethroids were most popular (57%), followed by organophosphates (25%) and carbamates (15%). Around 20% of the insecticides used belonged to WHO Toxicity Class I, while the rest nearly all belonged to Class II. Half of all the target sprays were done with three pyrethroid products only. Farmers' estimated yield loss due to insect pests was strongly correlated to estimated pest severity. Due to pesticide sellers' recommendations, farmer's sprayload significantly increased from 26 to 37 sprays per year, whereas the number of insecticide products used per farmer increased from 2.6 to 3.9 with advice from extension staff and media. Expenditure for pesticides was correlated with that of fertilizers. There was no relationship between the amount of pesticides sprayed and yield. On-farm research is needed to evaluate whether significant savings can be obtained given a more judicious use of pesticides. Only 10% of the 93 participating farmers knew about natural enemies, all of which were predators.

1. Introduction

The total fruit production area in the Mekong Delta, Vietnam increased from 92 000 ha in 1985 to 175 000 ha in 1995. During this period the government's policy has been to stress agricultural diversification, but conversion from paddy fields into fruit orchards is not actively stimulated because it might endanger Vietnam's position of second in the world rice export market. Conversion, however, is still taking place as many farmers prefer growing high value crops. After citrus and longan, mango is the third most important perennial fruit crop of the Mekong Delta, being cultivated over an area of 12 700 ha, and with an average yield of 9.3 t ha^{-1}. In 1995, 66% of Vietnam's national gross output for mango was produced in the Mekong Delta (DAFF, 1996).

Since the human population density is very high, farming systems are quite intensive and diversified. Farmers often share resources for both their orchard and irrigated rice fields. Fish culture is sometimes combined with fruit or rice cultivation.

Worldwide, sustainability of agricultural systems has received more and more emphasis over the past decades, though successes have been highly dependent on type of crop and region (Mengech *et al.*, 1995; Morse and Buhler, 1997). Perennial crops generally provide better opportunities to implement integrated pest management (IPM), due to their relatively stable ecosystems (Raheja, 1995). However, since perennial fruit crops are not considered as mandatory crops by the CGIAR, no large scale, coordinated research on pest management has been undertaken. In Vietnam, efforts to stimulate IPM have been mainly limited to rice production and more recently to tea and vegetable production (Van Mele, 1998). Introduction of the IPM concept in tropical fruit production is a new development in most countries (DOA and DOAE, 1995; PCARRD, 1994; Waite, 1998).

One of the major constraints upon establishing an IPM programme is the lack of adequate information about farmers' Knowledge, Perceptions and Practices (KPP) in pest management (Heong, 1985; Teng, 1987; Morse and Buhler, 1997). If scientists have to work with farmers to improve crop production and crop protection, they should recognize farmers' constraints and their existing technical knowledge (Kenmore, 1991; Bentley, 1992; Morse and Buhler, 1997). Knowledge of pests varies between farmers working in similar or different agro-ecosystems. In some cases, pest recognition is a major problem, while in others knowledge about pest ecology is the major constraint (van Huis and Meerman, 1997). Generally, farmers have good knowledge about easily observable and important objects (Bentley, 1992). However, farmers and scientists may differ in their opinion about the importance of a particular pest. This has been especially true for leaf-damaging pests in rice, to which farmers attribute substantial yield losses and subsequently target their sprays against these organisms (de Kraker, 1996; Heong and Escalada, 1997b; Mai *et al.*, 1997).

Evaluating farmers' knowledge and perception of pests and natural enemies is especially useful to set research agendas, for planning campaign strategies and developing messages for communication (Fujisaka, 1992; Escalada and Heong, 1993). Farmers' KPP in controlling rice pests has been well-documented (Fujisaka, 1990; Adesina *et al.*, 1994; Heong and Escalada, 1997b). Similar documentation is available for cotton (Ochou *et*

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al., 1998), cashew (Nathaniels, 1998), vegetables (Pollard, 1991; Trutmann *et al*., 1993, 1996; Burleigh *et al*., 1998), and subsistence crops (van Huis *et al*., 1982; Atteh, 1984; Chitere and Omolo, 1993; Bottenberg, 1995; Youm and Baidu-Forson, 1995), but it is non-existent for tropical fruit crops. Besides, relatively few scientific papers address farmers' pesticide use patterns, which in many cases in developing countries is a major component of pest management (Heong and Escalada, 1997b; Burleigh *et al*., 1998).

Our survey focused on mango farmers' decision-making, their knowledge, perception, and pest management practices. This information was used to (i) identify the pest problems that farmers perceive as most important; (ii) evaluate farmers' knowledge and practices in pest management, including farmers' pesticide use patterns; and (iii) identify gaps between research findings and farmers' practices.

2. Materials and methods

2.1. Study site

Three major fruit-growing areas in the Mekong Delta, South Vietnam, were covered in the study, namely Can Tho, Dong Thap and Tien Giang Provinces. Mean annual rainfall in the study area ranges from 1200 mm to 1600 mm with the dry season lasting from November/December to April/May. Average elevation of these three provinces is between 0.5 and 1.5 m above sea level, and large areas are prone to flooding during some periods of the year. The major soils of the fruit-producing areas are alluvial soils that have high natural fertility. Fruit orchards are mainly established along riverbanks and in the vicinity of canals.

A ridge cultivation system, with raised beds of 2–13 m wide, on which one to seven rows of fruit trees are grown, is most common. Planting beds are separated from one another by 1–8 m wide canals that are used for irrigation and transport of the harvested fruits. This cropping system is quite unique in the world and elsewhere can only be found in the lowland areas around Bangkok, Thailand (Othman and Suranant, 1995).

2.2. Survey

A survey was conducted from January to April 1998 in the major mango-producing provinces. A total of 93 mango farmers were interviewed. Sampling was stratified; major mango-growing districts within each of the three provinces were selected, and within each district orchards under production, with trees aged 4 years or older, were chosen randomly. In Can Tho, Chau Thanh district was selected and in Dong Thap, Cao Lanh district. In Tien Giang province, Cai Lay, Cai Be and Chau Thanh districts were sampled.

The questionnaire aimed to assess socio-economic, agronomic and pest management aspects in order to get a clear picture of the agro-ecosystem, decision-making and implementing actions in pest management. Farmers' KPP related to pests, natural enemies and pest management received special emphasis. The content of the questionnaire and type of questions asked was agreed upon after key informant interviews. To evaluate farmer's pest perception, they were first asked to record the most important pest problems. For each of the major pests, pest incidence, pest severity and estimated yield loss was ranked on a 3-level scale (low, moderate and high). The questionnaire was pretested and revised. On average, each questionnaire took 2-3 h of interview with each farmer, followed by a visit in the orchard. Since the period between flower induction and harvest takes 3–4 months, it was not always possible to cross-check farmers' answers regarding pest status with field observations. People involved in the survey were members of the Plant Protection Department, Cantho University. Survey data were encoded and statistical analyses were accomplished using SPSS statistical software. Percentages were based on the number of respondents rather than using the total sample. In cases where multiple responses were obtained, total sample size was used. Both parametric and non-parametric tests were conducted. The detailed procedures used are given in the text and the tables.

3. Results

3.1. Farmer profile

Table 1 summarizes the socio-economic profile of the farmers interviewed. Slightly more than 40% of the farmers were older than 50 years, and attended school for only 1–5 years, though age and educational level were not correlated. About 19% of the farmers interviewed had attended an extension course. Around 50% of the orchards selected were

Table 1. Profile of mango farmers and orchards in different provinces of the Mekong Delta, Vietnam, 1998

	Can Tho (n=9)	Dong Thap (n=47)	Tien Giang (n=37)	Tests[a]
Age of farmer (years)	45.3	47.2	52.0	NS
Education (years of school)	7.3	7.6	7.5	NS
Extension courses (%)				
Attended courses	0.0	13.0	32.4	*V*=0.28*
Age orchard (%)				
>10 years	88.9	43.4	51.4	*V*=0.26*
Field history (%)				
Paddy field	100.0	87.2	86.5	*V*=0.20
Waste land	0.0	4.3	8.1	*V*=0.11
Other orchard	0.0	8.5	5.4	*V*=0.11
Orchard size (ha)	1.5	0.6	0.5	Var***
Plant density (trees/ha)	231	382	460	Var*
Age of trees (year)	15.0	11.6	11.2	NS
Cropping pattern (%)				
Two or more varieties	55.6	10.9	13.5	*V*=0.35**
Mixed crops[b]	33.3	13.0	18.9	*V*=0.16
Animal integration	44.4	37.0	18.9	*V*=0.21
Major varieties[c] (%)				
Cat Hoa Loc	55.6	21.7	5.4	*V*=0.37**
Cat Chu	22.2	15.2	10.8	*V*=0.10
Ghep	11.1	65.2	91.9	*V*=0.51***
Hon Xanh	55.6	0.0	2.7	*V*=0.66***

[a]Tests conducted were one-way ANOVA (Var) or Chi-squared with Cramer's *V* to indicate strength of relation. NS = not significant, * significant at 5% level, ** at 1% level and *** at 0.1% level.

[b]Include rose apple (Can Tho and Tien Giang), longan (Dong Thap and Tien Giang) and lemon (Dong Thap).

[c]Sum of different varieties can be larger than 100% due to occurrence of more than 1 variety in some of the orchards.

established more than 10 years ago, indicating the farmers' years of experience in mango cultivation, except for those few cases where sons took over from fathers.

3.2. *Orchard profile*

Around 90% of the orchards were converted paddy fields (table 1). Two-thirds of the orchards were less than 0.5 hectare with nearly 80% under monocrop. Of those orchards under mixed cropping, 37% were mango mixed with longan (*Dimocarpus longan* Lour.), 32% with water apple (*Syzigium aqueum* Alston) and 21% with lime (*Citrus aurantifolia* Swing). Implementation of IPM has only been successful in those cases where the same crop was cultivated over a wide area (Morse and Buhler, 1997). This stresses the importance for small-scale Vietnamese fruit farmers to cooperate on a regional-wide basis. Major varieties covered in our survey were *Ghep* (71%), *Cat Hoa Loc* (18%) and *Cat Chu* (14%). *Cat Hoa Loc* was mainly restricted to Can Tho. Orchards in this Province were significantly older ($P<0.05$), larger ($P<0.001$) and consisted more of a mixture of different mango varieties (Cramer's $V=0.35$, $P<0.01$) compared with the other two Provinces. About one-third of the farmers bought seedlings from a nursery, and up to 85% of the trees were grown on their own rootstock. Animal husbandry was practiced among 30% of the farmers, which consisted mainly in rearing fish in the temporarily closed canals of their orchard.

There was no difference in farmer age or education level between the different Provinces, but significantly more farmers in Tien Giang had attended extension courses.

3.3. *Farmers' knowledge and perception of pests and natural enemies*

3.3.1. Insect pests. In response to the question concerning the major insect pests in their orchard, farmers on average mentioned 3.9 (SE = 0.2) different species. They described pests mostly as related to a particular symptom or by the plant part under attack.

The seed-borer, *Deanolis albizonalis* (Hampson) (Lepidoptera: Pyralidae), was mentioned by 89% of the farmers (table 2). Hoppers, *Idioscopus* spp. (Homoptera: Cicadellidae), were reported by 73%, and shoot-borers, *Chlumetia transversa* (Walker) (Lepidoptera: Noctuidae) and one other unidentified species, by 56% of the farmers. About 27% and 20% of the farmers mentioned flower-feeding and leaf-feeding caterpillars (Lepidoptera: Lymantriidae), respectively. Scales (Homoptera: Coccidae) and mealybugs (Homoptera: Pseudococcidae), were described by one-quarter of the farmers under the common name *rep sap*, whereas some farmers used *rep dinh* to describe

Table 2. Percentage of farmers recording major mango pests and spray targets in different provinces of the Mekong Delta, Vietnam, 1998

		Can Tho		Dong Thap		Tien Giang	
Common English name[a]	Local name	Pest	Target	Pest	Target	Pest	Target
Insects							
Seed-borer	Sau duc trai	100.0	88.9	91.5	87.2	80.6	75.0
Fruit fly	Ruoi duc trai	44.4	22.2	4.3	–	19.4	13.9
Flower-sucking hopper	Ray an bong	77.8	44.4	74.5	55.3	–	–
Flower-sucking hopper	Ray bong	22.2	11.1	–	–	77.8	66.7
Leaf-sucking hopper	Ray chich la	11.1	–	8.5	–	–	–
Green hopper	Ray nha	–	–	2.1	2.1	5.6	5.6
Flower-feeding caterpillar	Sau an bong	77.8	66.7	17.0	14.9	27.8	22.2
Flower-feeding caterpillar	Sau duc bong	22.2	22.2	–	–	–	–
Mealybugs and scales	Rep sap	55.6	33.3	17.0	10.6	30.6	22.2
Scales	Rep dinh	11.1	–	–	–	5.6	5.6
Shoot-borer	Sau duc canh	–	–	68.1	46.8	58.3	41.7
Shoot-borer	Sau duc ngon	–	–	2.1	2.1	2.8	2.8
Bark-borer	Sung duc than	77.8	22.2	2.1	–	5.6	2.8
Twig-borer	Bu xe	–	–	8.5	2.1	2.8	2.8
Leaf-feeding caterpillar	Sau an la	66.7	55.6	12.8	4.3	19.4	13.9
Leaf-webber	Sau o	–	–	25.5	19.1	–	–
Leaf-feeding weevil	Bo an la	–	–	6.4	4.3	–	–
Termites	Moi	–	–	2.1	–	8.3	8.3
Diseases							
Anthracnose	Than thu	88.9	55.6	53.2	44.6	50.0	33.3
Sooty mould	Bo hong	77.8	44.4	57.4	42.6	33.3	8.3
Frog skin spot	Da ech	–	–	61.7	34.0	25.0	22.2
Fruit burning	Da cam	44.4	22.2	46.8	23.4	13.9	13.9
Ring spot	Dom vong	–	–	–	–	38.9	33.3
Black spot	Dom den vo khuan	77.8	55.6	–	–	2.8	–
Trunk canker	Chay mu goc	–	–	8.5	–	5.6	2.8
Dead of branch	Kho canh	22.2	–	4.3	2.1	–	–
Fruit rot	Thoi trai	11.1	11.1	4.3	2.1	2.8	–
Leaf spot	Dom la	11.1	–	–	–	5.5	2.8

[a]Some pests could only be identified up to family level, some local names even refer to different pests belonging to different families. Scientific names are given in the text whenever possible.

scales. About 15% of the farmers reported problems with the fruit fly, *Bactrocera dorsalis* Hendel (Diptera: Tephritidae). The leaf-webber caterpillar, *Orthaga* sp. (Lepidoptera: Pyralidae) was only mentioned by farmers in Dong Thap and the bark-borer, *Plocaederus* sp. (Coleoptera: Cerambycidae) almost only by farmers in Can Tho.

Farmers' estimates of severity and yield loss due to the seed-borer and flower-sucking hoppers were rated significantly higher in Can Tho Province (table 3). Mealybug incidence had a higher rating in Tien Giang Province. In general, pest incidence was correlated with pest severity (Kendall's *tau-b*=0.40, $P<0.001$). Estimated yield loss due to insect pests was strongly correlated to estimated pest severity (Kendall's *tau-b*=0.75, $P<0.001$).

3.3.2. Diseases. Estimated yield losses for diseases were generally higher than for pests. The most frequently reported disease was *than thu*, referring to anthracnose *Colletotrichum gloeosporioides* (Penz.) Sacc. (table 2). Frog skin spot or *da ech* (of unknown aetiology) was mentioned by about 62% of the farmers in Dong Thap and 25% in Tien Giang. Total absence of this disease in Can Tho might be due to varietal differences. Farmers' description of a symptom sometimes referred to a particular disease such as sooty mould (*bo hong*) caused by *Capnodium* sp., whereas the symptom of fruit burn (*da cam*) could be due to causes ranging from sunburn, mites, thrips to scab. This symptom was reported by 33% of the farmers as a disease.

3.3.3. Natural enemies. Only around 10% of the farmers had any knowledge about natural enemies, all of which were predators. When asked how they knew about them, the only answer was that they had learned through their own observations. Six farmers mentioned spiders, two mentioned the weaver ant *Oecophylla smaragdina* (Fabricius) (Hymenoptera: Formicidae), and one reported swallows.

3.4. Pest management practices

Three farmers manually removed larvae of the shoot and bark-borer, one farmer cut flowers infested with scales or nymphs of hoppers (Homoptera). The majority (73.1%) of farmers pruned, mainly to control the shoot or twig-borer. Nearly all (97%) farmers used insecticides, and 79% used fungicides. About half of them possessed a knap-sack sprayer, and the other half had a power sprayer. Only one farmer spot-sprayed his trees after observing a high pest incidence. All the others applied total cover sprays.

3.5. Timing and frequency of pesticide applications

Insecticides were used at an average of 13.4 (SE=0.7) sprays per year ranging from 10 to 42, and fungicides were applied from 8 to 21 times per year, with an average of 11.6 (SE=0.6). Most sprays were applied from a few weeks before flowering (September/October) until harvest (February–April),

Table 3. Percentage of farmers estimating incidence, severity and yield loss of major mango insect pests in different provinces of the Mekong Delta, Vietnam

	Incidence				Severity				Yield loss			
Pest	CT[b]	DT	TG	Cramer's V[a]	CT	DT	TG	Cramer's V[a]	CT	DT	TG	Cramer's V[a]
Seed-borer												
low	0	0	7		0	38	39		14	42	27	
moderate	13	36	26	0.19	50	62	50	0.38***	29	58	41	0.43***
high	87	64	67		50	0	11		57	0	7	
Flower-sucking hopper												
low	13	9	0		0	42	26		0	58	80	
moderate	25	41	35	0.17	38	29	57	0.29*	20	23	20	0.44***
high	62	50	65		62	29	17		80	40	0	
Flower-feeding caterpillar												
low	0	0	0		17	29	67		0	43	70	
moderate	33	43	70	0.32	33	71	33	0.53*	60	57	20	0.46+
high	67	57	30		50	0	0		40	0	10	
Leaf-feeding caterpillar												
low	20	0	33		20	75	50		0	100	83	
moderate	0	60	67	0.55*	40	25	50	0.44	50	0	17	0.59
high	80	40	0		40	0	0		50	0	0	
Mealybugs and scales												
low	100	17	22		100	80	33		100	100	62	
moderate	0	67	22	0.58*	0	20	44	0.41	0	0	17	0.38
high	0	16	56		0	0	22		0	0	11	
Shoot-borer												
low	0	17	19		0	59	50		0	100	72	
moderate	0	48	48	0.05	0	34	44	0.10	0	0	17	0.36
high	0	35	33		0	7	6		0	0	11	

[a]Chi-squared was used to test significance. NS=not significant, +=significant at 10% level, * significant at 5% level, ** at 1% level and *** at 0.1% level.
[b]CT=Can Tho, DT=Dong Thap and TG=Tien Giang Province.

and fungicides were often mixed with insecticides. Nearly all of the farmers calendar sprayed on a weekly basis. Some even sprayed at 3–4 day intervals, mainly to protect fruits from seed-borer infestation. Nearly 50% of the farmers still sprayed insecticides 1–2 weeks prior to harvest, about one-third still applied fungicides. No monitoring was done and therefore sprays were merely prophylactic.

Some farmers who knew about natural enemies had a different attitude towards pesticides. On average, the majority (six out of nine) of them sprayed insecticides only 5.5 (SE = 1.2) times a year. The farmer who described both weaver ants and swallows as natural enemies sprayed only twice a year with insecticides.

3.6. Pesticide use

The majority of farmers (80.5%) mixed different insecticide products. On average, farmers targeted sprays against 3.3 (SE = 0.2) insect pests. From a total of 2073 intended targets, 33% were seed-borer, 26% flower-sucking hoppers, 15% shoot-borers, 8% flower-feeding caterpillars and 5% scales. More than 10% of the sprays targeted leaf-damaging insects (table 4). The average number of insecticide products used per farm was 3.0 (SE = 0.1). A total of 36 different insecticide products were used including 26 different active ingredients. Alpha-cypermethrin and cypermethrin were used under four and seven different trade names, respectively. This has seemingly confused some farmers as they mixed products with the same active ingredient. About 20% of the insecticides used belonged to WHO Toxicity Class I, the rest nearly all belonged to Class II. Pyrethroids were most popular (57%), followed by organophosphates (25%) and carbamates (15%) (table 4). Still more than 12% of the target sprays were of banned or restricted organophosphates, targeting several different pests. Half of all the target sprays was done with three pyrethroid products only, cypermethrin, esfenvalerate and lambda-cyhalothrin. More than 50% of all farmers in each of the provinces used cypermethrin (table 5).

A total of 18 different fungicides were used, including 11 different active ingredients. Major products used belonged to the group of systemic benzimidazoles, namely carbendazim (28.7%) and thiophanate-methyl (10.2%), and the group of dithiocarbamates, namely mancozeb (14%) and propineb (8.9%). Products belonging to other groups were chlorothalonil (9.6%) and metalaxyl (9.6%). Except for metalaxyl, which belonged to WHO Toxicity Class III, all fungicides belonged to Class V. From a total of 157 intended targets, 25% were anthracnose, 20% were sooty mould, 18% were frog skin spot and 17% were fruit burn.

3.7. Farmers' perception of pesticide advantages and disadvantages

Of the criteria used by farmers to make decisions to choose a particular pesticide, a fast knock-down effect of the product

Table 4. Insecticides used by farmers against mango target pests in the Mekong Delta, Vietnam

Insecticides	WHO toxicity class[b]	Target mango pests and % of insecticide used against targets[a]								Total	
		LW	LC	ME	FF	SHB	FH	FC	SB	no.	%
Organophosphates											
Methyl parathion	Ia	0.0	0.0	15.2	0.0	0.0	2.7	0.0	0.0	30	1.4
Methamidophos	Ib	3.1	6.5	0.0	15.7	3.3	1.6	0.0	1.8	49	2.4
Monocrotophos	Ib	19.9	0.0	5.1	0.0	14.4	2.2	5.0	2.8	120	5.8
Dichlorvos	Ib	0.0	0.0	0.0	0.0	5.2	0.0	10.1	5.5	69	3.3
Methidathion	Ib	0.0	10.4	25.3	0.0	0.0	15.9	8.8	2.4	150	7.2
Diazinon	II	0.0	0.0	14.1	0.0	0.0	9.5	0.0	4.6	97	4.7
Carbamates											
Fenobucarb (BPMC)	II	12.4	0.0	35.4	31.4	15.1	11.5	9.4	8.8	254	12.3
Carbaryl	II	0.0	0.0	0.0	0.0	0.0	8.6	0.0	2.2	62	3.0
Pyrethroids											
Alpha-cypermethrin	II	0.0	0.0	0.0	7.8	0.0	8.0	0.0	6.5	92	4.4
Cypermethrin	II	8.7	32.5	0.0	0.0	25.2	22.3	47.2	21.5	458	22.1
Deltamethrin	II	0.0	0.0	0.0	0.0	2.6	0.0	0.0	3.1	29	1.4
Esfenvalerate	II	55.9	23.4	0.0	19.6	12.1	10.2	8.8	17.1	340	16.4
Lambda-cyhalothrin	II	0.0	27.3	5.1	25.5	21.0	2.0	9.4	20.5	267	12.9
Others											
Fipronil	II	0.0	0.0	0.0	0.0	0.0	2.2	0.0	1.5	22	1.1
Buprofezin	III	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	12	0.6
Ethofenprox	IV	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0	17	0.8
Cypermethrin + profenofos	II	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	2	0.1
Fenvalerate + dimethoate	-	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3	0.1
Total no.		161	77	99	51	305	547	159	674	2073	100.0

[a]Many farmers applied insecticides for more than one pest at a time. Percentage of target sprays is based on total number of target sprays for each pest, given at the bottom of each column. [b]Ia = extremely hazardous, Ib = highly hazardous, II = moderately hazardous, III = slightly hazardous, V = unlikely to present acute hazard in normal use, - = unclassified. Source: Anonymous, 1999.

LW = leaf-webber, LC = leaf-feeding caterpillar, ME = mealybugs and scales, FF = fruit fly, SHB = shoot-borer, FH = flower-sucking hopper, FC = flower-feeding caterpillar, SB = seed-borer.

Table 5. Percentage of mango farmers using different insecticides in three different provinces of the Mekong delta, Vietnam

	Can Tho	Dong Thap	Tien Giang	Cramer's *V*[a]
Organophosphates				
Methyl parathion	22.2	0.0	8.1	0.30*
Methamidophos	33.3	2.1	13.5	0.32**
Monocrotophos	33.3	10.6	13.5	0.20
Dichlorvos	0.0	2.1	2.7	0.05
Methidathion	0.0	12.8	24.3	0.21
Diazinon	11.1	8.5	10.8	0.04
Fenitrothion	22.2	4.3	0.0	0.31*
Dimethoate	0.0	6.4	0.0	0.18
Carbamates				
Fenobucarb (BPMC)	11.1	23.4	27.0	0.11
Carbaryl	0.0	2.1	13.5	0.24+
Pyrethroids				
Alpha-cypermethrin	66.7	21.3	13.5	0.36**
Cypermethrin	55.6	53.2	56.8	0.03
Deltamethrin	33.3	25.5	10.8	0.20
Esfenvalerate	11.1	53.2	29.7	0.30*
Lambda-cyhalothrin	0.0	10.6	45.9	0.43***
Others				
Fipronil	0.0	4.3	0.0	0.15
Buprofezin	0.0	2.1	2.7	0.05
Ethofenprox	0.0	2.1	5.4	0.11
Cypermethrin + profenofos	0.0	2.1	2.7	0.05
Fenvalerate + dimethoate	22.2	2.1	0.0	0.36**
Fenobucarb + phenthoate	11.1	4.3	2.7	0.12

[a]Chi-squared was used to test significance: + = significant at 10% level, * significant at 5% level, ** at 1% level and *** at 0.1% level.

scored highest (68%), followed by familiarity (19%). Mango farmers were quite satisfied with the insecticides applied, as estimated efficiency ranged between 65% and 80%. Despite the high spray frequency with pyrethroids, farmers attributed a rather low insecticide efficiency against the mango seed-borer. Lowest insecticide efficiency was reported against scales and mealybugs. About 60% of the sprays targeting scales and mealybugs were with organophosphates (table 4). Disease control with fungicides was less efficient, ranging between 51% and 73%. Nearly 85% of the farmers applied KNO_3 to induce early flowering and produce off-season fruits. Flowering thus took place in the rainy season (September–November), making them more vulnerable to diseases. As fruit burn was wrongly diagnosed, control efficiency was rather low (53%). Mites and thrips were probably the causal agents, not fungi.

The advantages related to insecticide use (number of replicants = 27) were the good control provided by the product (100%), ease of use (19%) and ease of purchase (11%). From a total of 20 replicants, 80% mentioned health problems and 35% the difficulty of spraying very high trees as disadvantages.

Generally, Asian farmers perceive chemical inputs as being necessary to obtain high yields. To check whether similar conclusions could be made for mango farmers, we conducted a multiple regression analysis. Variance in yields, as reported by farmers, could be mainly explained by a model ($R^2 = 0.34$, $P < 0.001$) combining age of the trees (standardized regression coefficient $B = 0.43$, $P < 0.001$) and fertilizer expenditure ($B = 0.27$, $P < 0.01$). Expenditure for pesticides was correlated with that of fertilizers (Pearson $r = 0.32$, $P < 0.01$). Yield did not seem to be influenced by the amount of pesticides applied ($B = 0.08$, $P = 0.45$).

3.8. Information transfer

To understand the major influences on farmers' decision-making, they were asked about their major sources of pesticide advice. Regional differences occurred (figure 1). Farmers in Can Tho relied mainly on their own experience (89%) and media advertisements (56%), whereas pesticide sellers were significantly more reported by farmers in Dong Thap and Tien Giang Province (Cramer's $V = 0.23$, $P < 0.05$). They were less important in Can Tho as mango is a minor crop in this Province. Hence pesticide sellers have mainly concentrated their efforts on other crops such as rice and vegetables. The Extension Service was most significant in Tien Giang Province, clearly influenced by the presence of the Southern Fruit Research Institute (Cramer's $V = 0.35$, $P < 0.01$).

In general, the majority (71%) reported 'trusting on their own experience' for pesticide advice. As nearly all mango farmers excessively used pesticides and a fast knock-down effect was their major pesticide criterion, building on their own experience is a rather negative aspect. Besides, the information source of their own experience was correlated with pesticide advertisements in the media (Cramer's $V = 0.24$, $P < 0.05$). About 44% of the farmers obtained advice from the pesticide advertisements in the media and an equal amount from the pesticide sellers (multiple answers). Extension staff and neighbours were less important (18%) sources of information. A strong correlation ($\gamma = 0.84$, $P < 0.001$) existed between attending extension courses (no course, one or two courses and more than two courses attended) and relying on extension staff for pesticide advice.

GLM general factorial analysis (main effects) were conducted to find out which production characteristics and pesticide information sources discriminated best for differences in the number of pesticide products and sprays applied. Only information sources seemed to be significant. More different pesticide products were applied by farmers getting pesticide advice from the extension staff (regression coefficient $B = 0.65$, $P = 0.08$) or media ($B = 0.52$, $P = 0.07$). The number of insecticide products used per farmer increased from 2.6 (SE = 0.2) to 3.9 (SE = 0.2) when relying both on extension staff and media for pesticide

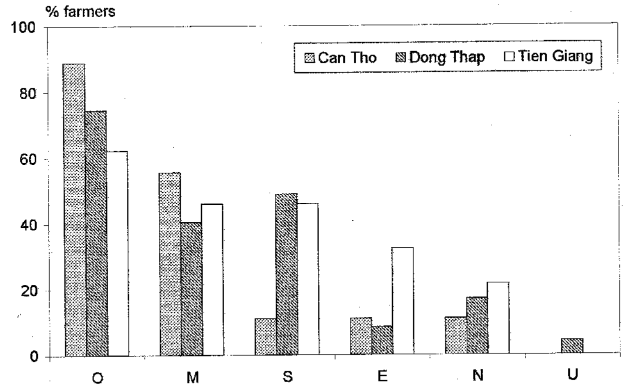

Figure 1. Regional differences in sources of pest management information influencing farmers' decision-making. O = own experience, M = media, S = pesticide seller, E = extension officer, N = neighbour, U = university staff.

advice. Farmers getting advice from extension sprayed less frequently ($B=-3.32$, $P=0.07$), but overall sprayload was not influenced. Farmers' sprayload was higher for those relying on their own experience ($B=9.98$, $P=0.05$) or the pesticide seller ($B=10.10$, $P=0.03$). Due to pesticide sellers' recommendations, farmers' sprayload increased from 26.0 (SE = 3.1) to 36.8 (SE = 3.6) sprays per year.

4. Discussion

4.1. *Knowledge and perceptions of pests and natural enemies*

The major mango pests reported by farmers in the Mekong Delta have also been described as major problems in Indonesia and the Philippines (Cunningham, 1984; PCARRD, 1994), and in Thailand with the exception of the seed-borer (DOA and DOAE, 1995). Differences in pest perception occurred between provinces. Shoot-borers (*sau duc canh* and *sau duc ngon*) were not mentioned by farmers in Can Tho Province. This might be due to a variety of reasons such as differences in size and age of the trees, which makes observations more difficult, and differences in varieties, cropping system, or geographical distribution of the pest. Farmers in Can Tho Province perceived leaf-feeding caterpillars as more problematic compared with farmers in other provinces. This could be attributed to the fact that mango farmers in Can Tho lacked proper training, as was also the case for citrus in this province (Van Mele, Cuc, Thas and van Huis, unpublished).

Some farmers ($n=6$) made a distinction between a flower-sucking hopper (*ray an bong*) and a leaf-sucking hopper (*ray chich la*). It is possible that different hoppers occur. However, flower-sucking hoppers are already causing damage during the flushing stage, after which they gather on the underside of mature leaves (DOA and DOAE, 1995). That pests are considered one at a time, with no attempt to view them in an integrated sense, is one of the characteristics that equates much more closely to pest control than pest management (Morse and Buhler, 1997). It might also indicate that farmers pay no or less attention to pests during the vegetative phase.

During our survey, about 15% of the farmers reported problems with fruit flies, which according to the farmers could highly reduce yields. However, during field studies from 1994 to 1996, fruit flies occurred in fewer than 2% of the mango orchards, and therefore are not considered a serious problem in mango in the Mekong Delta of Vietnam (Cuc *et al.*, 1998). Therefore farmers have most likely confused fruit fly damage with that caused by the seed-borer. A few years ago, confusion between these two pests was very common, but through media and extension activities, this situation has in general improved (Cuc, personal communication). None of the farmers reporting fruit flies had ever attended an extension course. Waterhouse (1998) finds it remarkable that there are so very few references to mango seed-borer in the literature. He is tempted to postulate that the damage actually due to the seed-borer is commonly attributed to other causes.

Generally, farmers' knowledge about diseases was less extensive than their knowledge about insects and attributed yield losses due to diseases were higher. The symptom of fruit burn (*da cam*) could be due to a variety of causes such as sunburn, mites, thrips or scab. This symptom was reported as a disease by 33% of the farmers, mainly in Can Tho and Dong Thap Province. In these two provinces citrus is a popular crop with mite damage symptoms equally described as *da cam* disease by untrained farmers (Van Mele, Cuc and van Huis, unpublished). About 20% of the fungicide sprays targeted this symptom in mango. This illustrates that mango farmers also do not always make the link between causal agent and damage symptom, and therefore often erroneously treat symptoms. This missing link is particularly common in respect to smaller organisms such as diseases (Bentley, 1992; Trutmann *et al.*, 1996; van Huis and Meerman, 1997) and mites (Van Mele, Cuc and van Huis, unpublished). Farmers attribute symptoms of anthracnose on leaves to a disease. Symptoms of anthracnose on flowers, on the other hand, were not attributed to a disease, but to humid, foggy mornings. In the Central African highlands, farmers often related bean disease symptoms to the effects of various forms of moisture (Trutmann *et al.*,1996). Cashew farmers in Tanzania attributed powdery mildew (*Oidium anacardii*) to mist (Nathaniels, 1998).

Mango farmers in the Mekong Delta have no knowledge of the existence of smaller organisms such as predatory mites, parasitoids or entomopathogens, because they are difficult to observe (Bentley, 1992), or because their effect is difficult to interpret. Only a few farmers perceived some larger, predatory species in their mango orchard. The general high size of mango trees is possibly a limiting factor in farmers' perception and hence knowledge acquisition. In Malaysia, the weaver ant *O. smaragdina* is an important predator of the large mango tip-borer *Penicillaria jocosatrix* (Guenee) (Lepidoptera: Noctuidae) (Khoo *et al.*, 1993). Also in citrus in the Mekong Delta, *O. smaragdina* is an important predator and therefore actively taken care of (Van Mele and Cuc, 2000). Besides, this ant species is widely known by all people in the Mekong Delta, also by non-farmers. Despite *O. smaragdina* being present in 10 mango orchards, it was surprising that only two farmers perceived it as beneficial. Training of farmers should definitely take this lack of knowledge or appreciation into account.

4.2. *Pest management*

In the Mekong Delta, the pattern of pesticide use in mango is very similar to that in rice, with 99% and 76% of the rice farmers spraying insecticides and fungicides, respectively (Heong and Escalada, 1997b). The fact that most orchards are converted paddy fields and that many farmers share their resources for both irrigated rice fields and orchards might explain this similar pattern of pesticide use. Fear of yield loss, commercial advertisements of chemical companies, lack of information or lack of knowledge about pests and natural enemies are some of the factors which can lock farmers into calendar spraying (Escalada and Heong, 1993; Norton, 1993; Schwab, 1995), as is the case for mango farmers in the Mekong Delta.

In rice, farmers' pesticide decisions do not seem to be based on economic rationale. These decisions, often made under uncertainty, are influenced more by perceptions of the pest and expected benefits from spraying (Waibel, 1986; Heong *et al.*, 1994; Heong and Escalada, 1997b). In mango, yield did not seem to be influenced by the amount of pesticides applied. Evaluation of whether significant savings can be obtained given a more judicious use of pesticides is recommended.

Pesticides were primarily used for prevention, as when targeting the seed-borer, or after observing damage symptoms, for instance in case of leaf-damaging pests. Similarly, rice farmers overreact to leaf-feeding insects, since they strongly believe that these pests reduce yield (Heong *et al.*, 1994; de Kraker, 1996; Mai *et al.*, 1997). Some mango farmers equally targeted leaf-feeding caterpillars and leaf-webbers. Farmer participatory experiments should be conducted to evaluate whether these pests affect the yield or not. In the Philippines, Golez (1991) effectively controlled the mango seed-borer with four applications of cyfluthrin or deltamethrin at 60, 75, 90 and 105 days after fruit induction. Both in the Philippines and Australia, all major mango pests and diseases combined can be controlled with five to eight pesticide applications, when they are properly timed (Bondad, 1989; Cunningham, 1989; PCARRD, 1994). Numerous pesticide applications could also probably be saved in Vietnam, given a better knowledge of the pests and a more realistic estimate of the damage being caused.

Mango farmers have a tendency to spray insecticides with a fast knock-down effect, as has been described earlier for rice farmers (Heong and Escalada, 1997b; Normiyah and Chang, 1997). Besides, at least for the Mekong Delta, this mentality remained unchanged even after farmers had attended IPM courses in a farmer field school (Chung and Dung, 1996).

From 1994 to 1998, the number of pesticide products, mainly pyrethroids, used by fruit farmers in the Mekong Delta has increased by nearly 200% (Van Mele and Hai, 1999), illustrating the high interest chemical companies have in the Vietnamese market. In many industrialized countries, the excessive use of synthetic pyrethroids in tree fruit crops has led to pest resistance, a decrease in natural enemies and increased problems with scales and mealybugs (Waite, 1998). The use of the banned and restricted products methyl parathion, monocrotophos and methamidophos has decreased by 50%, but is still substantial (Van Mele and Hai, 1999). Although methyl parathion was no longer supposed to be imported in Vietnam, residual stocks were still available. Anonymous (1997) described a lack of policy or enforcement of legislation on the import of chemicals as one of the existing problems to introduce IPM in Vietnam. Broad-spectrum insecticides can cause a resurgence of scales and evoke outbreaks of secondary pests such as thrips and mites, which in turn require further chemical treatments (De Faveri and Brown, 1995; Waite, 1998). Besides, continued use of the same insecticides has already caused resistance of scales against several organophosphates and carbamates (Grafton-Cardwell and Reagan, 1995; Waite, 1998).

4.3. Pesticide information sources

In rice in Vietnam, the excessive use of insecticides seems to be associated with prominent advertising (Mai *et al.*, 1993). Marketing techniques of the chemical industry obviously have a very strong influence on farmers' choice to use chemicals as the only solution to avert the risk of pests. No attention is paid to products available on the market being toxic to highly toxic. Pesticides are always promoted on their curing effects and their poisonous effects are often neglected. Communication media have, on the other hand, been successfully applied to change rice farmers' pest management practices in the Mekong Delta (Heong *et al.*, 1998).

It is well recognized that pesticide sellers have a stronger presence than extension agents in many farming communities and are sought by farmers for advice because of their accessibility (Heong and Escalada, 1997a; Van Mele, Cuc, Thas and van Huis, unpublished). In many developing countries, major shortcomings of the extension service are responsibility for numerous other tasks, lack of adequate training, material shortages, centralist decision-making structures combined with a poor 'top-down' flow of information, and that extension messages are not in line with farmers' needs (Daxl *et al.*, 1994). Similar shortcomings for IPM extension in Thai fruit production were described by Nayman (1990). Farmer participatory IPM is proving an effective means of building successful farmer extension systems on the scale necessary to meet the needs of small-holders in developing countries (van de Fliert, 1993; Matteson, 1996; Stock, 1996; Waage, 1998).

In the Philippines and Thailand, many rice farmers admitted that seeing their neighbours spraying their field often prompts them to spray as well, even though it is not necessary (Escalada and Heong, 1993). Fields with annual crops have open habitats making social control and interpersonal contacts an important factor in information exchange. This is true both for pesticide misuse (Escalada and Heong, 1993; Burleigh *et al.*, 1997; Tjornhom *et al.*, 1997) and for the spread of sound IPM practices (van de Fliert, 1993; Heong and Escalada, 1997a; Heong and Escalada, 1998). Orchards are, however, more closed habitats and every farmer can act more freely as he thinks is best. Physical or visual barriers and competition between farmers, among other reasons, make that farmer-to-farmer exchange of information is less common in fruit production in the Mekong Delta (Van Mele, Cuc, Thas and van Huis, unpublished). This situation necessitates even more the need of proper farmer training. Farmer-to-farmer learning could afterwards also be enforced through existing farmers' associations or other local organizations.

The importance of distilling information from a high science to a low-technology level by creating easily testable hypotheses, so called heuristics, has been proven to be very successful in information transfer to rice farmers (Castillo, 1996; Heong and Escalada, 1998). As research on fruit crops in Vietnam is in its infancy, it would take too much time to create heuristics that are based on accurate scientific knowledge of the agro-ecosystem. Based on both farmers' KPP and currently available scientific knowledge, farmer participatory research and extension activities should be developed. Farmers' involvement from the early stages of research will reduce the risk of their becoming lost in the labyrinth of research, or ending up with integrated pest management packages that are rejected by farmers (Morse and Buhler, 1997).

Mango farmers in the Mekong Delta, Vietnam, have so far been convinced and stimulated to use chemical inputs as the only means of crop production and protection. Pesticide advertising in the media, pesticide sellers and in many cases extension officers have created and promoted this tendency. It is imperative that participatory research and mass media campaigns be commenced to show farmers that alternative, more sustainable approaches for pest and disease management are possible.

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