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Influence of pesticide information sources on citrus farmers' knowledge, perception and practices in pest management, Mekong Delta, Vietnam

(*Keywords: Oecophylla smaragdina*, knowledge systems, communication, pesticides, biological control, citrus, Vietnam)

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Abstract. In 1998–99, about 150 citrus farmers and 120 pesticide sellers were interviewed in Can Tho and Dong Thap province, Mekong Delta, Vietnam. Media, pesticide sellers and extension staff had different influences on farmers' pest perception and management practices depending on the region and intensity of the cropping system. Pesticide sellers were notified by about 95% of the farmers about their major pest problems, and the type of pesticides sold in their shop was primarily based on farmers' demand (87%) and then on company promotion (56%). Those farmers relying on pesticide sellers used more of the banned insecticide methyl parathion. Probably for fear of being accused of illegal practices, none of the pesticide sellers mentioned that they recommended this product or that farmers asked for it. In the intensive Tieu mandarin cropping system, media and extension activities increased farmers' knowledge of difficult-to-observe pests such as the citrus red mite *Panonychus citri* and thrips, *Thrips* sp. and *Scirtothrips* sp. Since extension was weak in sweet orange, those farmers exposed to media only reported the damage symptom of mites, not knowing the causal agent. Media alone seemingly did not suffice to acquaint farmers with these small organisms. Farmers getting advice from the media advertisements applied more different pesticide products and sprayed insecticides more frequently, whereas the extension has stimulated the use of acaricides and increased the number of both insecticide and fungicide sprays. The traditional practice of biological control with the ant *Oecophylla smaragdina* might be endangered with growing media influence and when extension activities remain confined to chemical pest control. Constraints and potentials of different information sources are discussed in relation to developing IPM programmes for citrus.

1. Introduction

One of the major constraints in establishing an IPM programme is the lack of adequate information about farmers' knowledge, perceptions and practices (KPP) in pest management (Norton and Mumford 1982, Atteh 1984, Kenmore 1991, Morse and Buhler 1997, Van Mele 2000). Knowledge of pests not only varies among farmers working in different agro-ecosystems, but also among those working in similar ones (Altieri 1993, van Huis and Meerman 1997, Debrah *et al.* 1998). Evaluating farmers' KPP is especially useful to determine information gaps, to set research agendas, to assess the impact of different information sources, to plan campaign strategies and to develop messages for communication (Kenmore *et al.* 1987, Fujisaka 1992, Escalada and Heong 1993, Mumford and Norton 1993, Heong *et al.* 1998). Farmers' KPP in controlling pests have been well documented for rice (Adesina *et al.* 1994, Heong and Escalada 1997) and some other crops, but it is nearly unknown for tropical fruit crops. Moreover, relatively few papers address farmers' pesticide use patterns, which in many cases in developing countries are a major component of pest management (Heong and Escalada 1997, Burleigh *et al.* 1998).

The present survey focused on citrus farmers' KPP in pest management and how it was influenced by different sources of pesticide information. Of particular interest were: (1) the kinds of pests that farmers perceived as problematic, (2) farmers' use of agrochemicals and their spray patterns, and (3) the traditional use of the weaver ant *Oecophylla smaragdina* (Fabricius) (Hymenoptera: Formicidae) as a biological control agent.

2. Materials and methods

The information provided here was derived from different sources, including two surveys, interviews and media analysis.

From January to April 1998, 150 citrus farmers, cultivating mainly sweet orange (*Citrus sinensis* (L.) Osbeck) and Tieu mandarin (*C. reticulata* Blanco), and to a lesser extent sweet mandarin (*C. reticulata*) and king orange (*C. nobilis* Lour.), were interviewed in Can Tho and Dong Thap provinces, Mekong Delta, Vietnam. Sampling was stratified according to the production area of each citrus species. Within each stratum, farmers were randomly selected based on a list at the Service of Agriculture and Rural Development. One criterion was that orchards had to be at least 4 years old. Sweet orange, sweet mandarin and king orange cultivation was mainly restricted to Can Tho province, and farmers were interviewed in Can Tho city, Chau Thanh and Omon districts ($n=72$). Tieu mandarin is very susceptible to flooding and therefore is mainly grown in those areas with a slightly higher elevation and on soils that allow better drainage. Sampling for Tieu mandarin was consequently carried out in Omon district of Can Tho province and in Lai Vung district, Dong Thap province ($n=78$).

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The content of the questionnaire and the type of questions asked were agreed upon after key informant interviews and were modified after being pretested on a small group of farmers in both provinces. On average, each questionnaire took 2–3 hours of interview with each farmer. People involved in the survey were members of the Plant Protection Department, Cantho University. The questionnaire aimed to get a clear picture of the farming system in general, and about the farmers' knowledge, their perceptions and the pest management they carried out particularly. Both structured and semistructured open questions were used as described by Mumford and Norton (1993). Farmers were asked to record their most important pest problems and to indicate where they got information about pesticide use. They could choose one or more out of the following list: own experience, media, pesticide sellers, neighbours, extension staff, university staff, staff from research institute or other. Although no explicit distinction was made for media, previous studies in the Mekong Delta have indicated that television was more important than the radio for both fruit farmers (Dang 1997) and rice farmers (Chung and Dung 1996). In cases where pesticides were used, farmers were asked to specify which products they used and how many times, when they sprayed and which pests were targeted.

Surveys of experts assessed the content and importance of different information flows towards farmers. Information about extension activities was obtained through interviews with key persons from the Extension Service in the different districts. Staff from the Plant Protection Department and Cantho University were also interviewed. In general, the Plant Protection Department was not very familiar with pest management in fruit crops, but had an indirect impact on fruit farmers by giving training courses to pesticide sellers. Media activities were recorded and analysed at regular times throughout the study period.

Specific information about the pesticide seller's knowledge of pests and pesticides, and their interaction with the farmers was obtained from a separate survey conducted at the end of 1998 and the beginning of 1999. In those districts where the farmer survey had been conducted, about 120 pesticide shop owners were randomly selected and interviewed using a questionnaire. Fifty-two reported that they sold pesticides to citrus farmers on a regular basis. The pesticide sellers were also asked to list, according to them, the four most important pests and diseases. Finally, they were presented with a list of the 10 most important citrus pests and diseases and asked to record up to three different products that they would recommend for each of them.

Survey data were encoded using spreadsheet software programs and statistical analyses were accomplished using SPSS statistical software. Chi-squared and Cramer's V were calculated to indicate correlations between dichotomous variables. Logistic regressions were conducted for dichotomous variables such as the information source and use of agrochemicals. In addition to these dichotomous variables, other variables included in the analyses were: production regions (four districts entered as dummy variables), farmers' age and education (years), the size (ha) of the orchard and age (years) of the trees, the type of major fruit species (Tieu mandarin, sweet orange and others entered as dummy variables), mixed or monoculture (dichotomous), the plant density (trees ha^{-1}), and high weaver ant populations or not (dichotomous). Detailed information about these variables has been given by Van Mele and Cuc (2000) and Van Mele, Cuc and van Huis (2002). Calculations routinely included all independent variables. At each step, the variable with the highest *p* was omitted until only significant ($p \leqslant 0.05$) variables remained in the model (Backward Model Selection). To enable comparisons of the types of pesticides used and the types of pests reported between the different information sources, one general model was built including all the variables that were significant in at least one of the individual models of each information source (Agresti 1990). Odds ratios (OR) are given for each independent variable. An OR <1 indicated that the probability that the dependent variable occurs is smaller than the probability in the reference class of the independent factor (the reference class always indicates the absence or negation of the independent variable), and vice versa when OR >1. Degrees of freedom (d.f.) = 1, unless stated otherwise.

GLM general factorial analyses allowing for two-way interactions were conducted to find out which production characteristics and pesticide information sources discriminated for differences in the number of pests reported, the number of pesticide products applied and the number of sprays. The regression coefficients *B* and their respective *p* are given for all significant variables and interactions.

3. Results

3.1. *Who receives pesticide advice, where and from whom?*

About 60% of the farmers relied on their own experience for pesticide advice, 40% on media advertisements and 20% on pesticide sellers, followed by extension officers (17%), neighbours (7%) and university staff (5%) (figure 1). Analysing the within-district correlation of different information sources, own experience was strongly correlated with advice from the media in Can Tho city (Cramer's V = 0.919, $p < 0.001$), and with advice from the pesticide sellers in Chau Thanh district (Cramer's V = 0.407, $p = 0.023$). Logistic regression analysis revealed that the production area and type of citrus species cultivated had the most discriminating power. The significant variables were grouped in one model to make comparisons between the different information sources possible (table 1). Chau Thanh district was omitted from the model to avoid colinearity.

The media were the most important source of pesticide information for farmers in Can Tho city, which hosts the biggest television station in the Mekong Delta, and the pesticide sellers had most influence in Chau Thanh district (OR = 3.32, $p = 0.007$). Extension was most significant in Lai Vung district, Dong Thap (table 1). The Extension Service of this province has a strong programme supporting fruit production, whereas in Can Tho province extension mainly focused on rice and vegetable production. Neighbours were only important for information exchange in Tieu mandarin, irrespective of the province.

Most of the pesticide sellers had a high education level, on average 9.8 (SE = 0.4) years of school, and they had been in the business for about 7.0 (SE = 0.7) years. Some learnt about pests by self-study in books or by observing pests in their own orchard (table 2). The farmers mainly informed them about the current

Table 1. Odds ratios (p) of production characteristics for different sources of pesticide advice, Mekong Delta, 1998 (n=150). **Bold** *indicates discriminating variables at p⩽0.05 for individual models of the information source*

	Own experience	Media	Pesticide seller	Extension officer	Neighbour
Omon district	**5.57** (0.00)	1.72 (0.35)	0.39 (0.16)	0.36 (0.41)	–[1]
Can Tho city	2.57 (0.06)	**3.73** (0.02)	0.24 (0.04)	1.41 (0.69)	–
Lai Vung district	1.91 (0.36)	1.84 (0.37)	0.67 (0.63)	**10.68** (0.03)	–
Tieu mandarin	0.77 (0.64)	0.91 (0.85)	0.51 (0.34)	0.41 (0.35)	**3.00** (0.34)

[1]Odds ratios could not be calculated because of insufficient data.

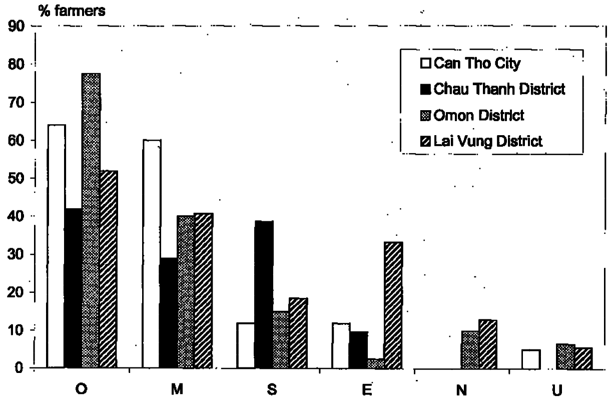

Figure 1. Sources of information influencing farmers' decision-making related to pesticide use in different citrus production regions. O, own experience; M, media; S, pesticide seller; E, extension officer; N, neighbour.

Table 2. Percentage of pesticide sellers reporting the source of information for different aspects of pest management, Mekong Delta, 1998–99 (n=52)

	Where did the pesticide seller learn about:		
	Pests	Current pest problems	Products
Farmer	9.6	69.2	84.6
Company	0.0	13.5	69.2
Media	0.0	9.6	59.6
Leaflets	0.0	0.0	38.5
Plant Protection Department	7.7	9.6	32.7
Extension Service	0.0	0.0	28.8
Cantho University	0.0	0.0	25.0
Books	26.9	0.0	0.0
Own experience	15.4	0.0	7.7
Nowhere	0.0	3.8	0.0

pest problems and about the performance of pesticides. Information about pesticides was also obtained from activities organized by the chemical companies and from media advertisements. The Plant Protection Department and Extension Service hardly seemed to contribute to the pesticide sellers' knowledge about pests.

3.2. Pest problems

The number of insect pests reported by farmers depended mainly on the pesticide information source, of which media was most significant (table 3). A list of major insects, pests, and diseases in citrus in the Mekong Delta was given in Van Mele, Cuc and van Huis (2002).

The citrus leafminer *Phyllocnistis citrella* (Lepidoptera: Gracillariidae) was the most frequently mentioned insect pest by farmers irrespective of the crop, production region or information source. Pesticide sellers (85%) also reported it as the most important pest in citrus. As the pest, along with citrus greening, was not discriminated by any of the variables, it was not presented in table 4. The citrus stinkbug *Rhynchocoris humeralis* (Hemiptera: Pentatomidae) and mealybugs *Planococcus citri* (Risso) (Homoptera: Pseudococcidae) were mainly mentioned by farmers who relied on their own experience for purchasing pesticides (table 4). The pesticide sellers were notified by >90% of the farmers about their major pest problems. The stinkbug and mealybugs were mentioned by about 25 and 50% of the pesticide sellers as major citrus pests. Despite the fact that citrus greening has been the major topic for fruit extension activities in Can Tho province since 1994, it is surprising that only six farmers and one pesticide seller reported its vector, the psyllid *Diaphorina citri* (Kuwayama) (Homoptera: Psyllidae), as a pest problem.

The source of pesticide advice may affect farmers' knowledge of pests, and especially of those that are difficult to observe. Thrips, *Thrips* sp. and *Scirtothrips* sp. (Thysanoptera) were only reported by farmers who relied on the extension staff and/or media for their pesticide advice (table 4). The citrus red mite *Panonychus citri* (McGregor) (Acarina: Tetranychidae) was mainly mentioned as a pest problem when the neighbour or the extension staff was an important pesticide information source. The symptoms caused by the citrus red mite and citrus rust mite *Phylocoptruta oleivora* Ashmead (Acarina: Eriophyiidae), on the other hand, were reported as diseases mainly by farmers depending on the media for advice. One extension video dealing with mites had been made by staff from the Cantho University in collaboration with the Extension Service. It was broadcasted at regular intervals at the beginning of each fruiting season. Although images of mites were displayed, they seemingly did not contribute to the farmers' knowledge of the organism. With pictures, pests were magnified so much that they no longer reflected the real situation. Some extension activities with field visits and the provision of hand lenses were conducted to assist farmers in recognizing mites. However, during our survey, only some farmers were observed to have hand lenses. Considering that mites are very small, highly mobile creatures and therefore difficult to observe under field conditions, it is surprising that 75% of the Tieu mandarin farmers in Dong Thap mentioned mites in their orchard (Van Mele, Cuc and van Huis, 2002). Most farmers have probably never observed mites, and just sprayed their orchard prophylactically based on extension and media advice. Tieu mandarin farmers indeed calendar-sprayed their orchard against mites from flowering until harvest (Van Mele and van Lenteren 2002). Farmer training through extension seminars or mass media, out of the context of their own field, indeed has often led to such situations where farmers were told which pests they had and how to control them chemically (Escalada and Heong 1993, Van de Fliert 1993). In such cases, it is not the farmer but the extension staff, scientist or media who is the decision-maker. Tieu mandarin farmers are seemingly highly receptive to the information provided. Whether they actually know mites should be further investigated by confronting them with life samples.

Some pests are apparently not dealt with in the media or extension activities. For instance, farmers ask pesticide sellers for advice about controlling some easily observable pests such as leafrollers (unidentified; Lepidoptera: Tortricidae) and stem borers (Coleoptera: Cerambycidae).

Table 3. General linear model parameter estimates for the number of insect pests and diseases reported by citrus farmers (n=150), Mekong Delta, 1998

	No. of insect pests		No. of diseases	
	B[1]	*p*	*B*	*p*
Own experience	0.72	0.028	0.79	0.006
Media	1.33	<0.001	1.64	<0.001
Extension	–	–	1.05	0.006
Omon district	–	–	1.74	<0.001
Intercept	3.72	<0.001	2.59	<0.001

[1]B, regression coefficient; *p*, probability.

3.3. Use of agrochemicals

Insecticide use was correlated with fungicide use (Cramer's $V = 0.439$, $p < 0.001$) and foliar fertiliser use (Cramer's $V = 0.206$, $p = 0.012$). Whether farmers used insecticides depended mainly on the presence of the ant *O. smaragdina* (table 5). Sweet orange farmers in Can Tho province often refrained from spraying insecticides to conserve *O. smaragdina* as a biological control agent in their orchard (Van Mele and Cuc 2000).

Fungicide use was best indicated by Tieu mandarin and whether farmers relied on the media for pesticide advice. Most farmers reporting scab, *Elsinoë fawcettii* Bitanc. *et* Jenkins, applied fungicides. Daily agricultural programmes are broadcast

Table 4. Odds ratios (p) of major pests reported by farmers relying on different sources of pesticide advice, Mekong Delta, 1998 (n=150). **Bold** *indicates discriminating variables at p ⩽ 0.05 for individual models of information source*

	Own experience	Media	Pesticide seller	Extension officer	Neighbour
Insect pests					
Stinkbug	**2.60** (0.03)	0.83 (0.68)	1.07 (0.89)	0.57 (0.32)	0.43 (0.29)
Mealybugs	**3.95** (0.00)	1.31 (0.57)	0.70 (0.49)	0.64 (0.44)	0.48 (0.43)
Leaf-feeding caterpillar	2.78 (0.05)	**4.40** (0.00)	1.26 (0.67)	0.98 (0.97)	–[1]
Leafroller	0.77 (0.63)	1.63 (0.40)	**2.76** (0.07)	0.28 (0.27)	–
Stem borer	0.43 (0.45)	0.19 (0.00)	**27.20** (0.02)	1.45 (0.79)	–
Thrips	1.72 (0.55)	**8.79** (0.02)	1.10 (0.94)	**12.95** (0.00)	0.73 (0.83)
Mites	0.59 (0.26)	1.52 (0.39)	0.87 (0.80)	**2.44** (0.11)	**8.24** (0.01)
Diseases					
Red mite symptom	**3.60** (0.06)	**4.04** (0.02)	1.86 (0.32)	1.24 (0.77)	–
Rust mite symptom	1.37 (0.65)	**4.66** (0.03)	0.41 (0.28)	2.36 (0.24)	7.65 (0.14)
Sooty mould	2.00 (0.18)	**2.65** (0.05)	0.76 (0.63)	0.49 (0.29)	1.83 (0.56)
Brown spot	0.86 (0.73)	0.89 (0.79)	0.77 (0.59)	**2.47** (0.11)	**0.17** (0.05)

[1]Odds ratios could not be calculated because of insufficient data.

Table 5. Odds ratios (p) from logistic regression models for use of agrochemicals based on the production characteristics, pesticide information sources and pests mentioned by farmers, Mekong Delta, 1998 (n=150)

	Insecticide use	Fungicide use	Herbicide use	Foliar fertilizer use
Can Tho city	–[1]	–	4.39 (0.006)	–
Omon district	4.39 (0.020)	–	–	–
Lai Vung district	10.74 (0.035)	–	–	–
Tieu mandarin	–	14.99 (0.00)	–	–
Size orchard	–	–	1.16 (0.013)	–
Mixed orchard	4.97 (0.020)	–	–	–
O. smaragdina	0.08 (0.018)	–	–	–
Age of farmer	–	–	0.96 (0.033)	–
Media	–	3.28 (0.014)	–	2.15 (0.065)
Own experience	–	2.99 (0.020)	2.65 (0.035)	–
Neighbour	–	–	7.74 (0.007)	–
Thrips	–	–	8.46 (0.016)	–
Aphids	–	–	–	2.01 (0.074)
Mealybugs	–	–	–	3.50 (0.004)
Scab	–	2.61 (0.041)	–	–

[1]Non-significant variables were omitted from the model.

by Cantho TV in all the provinces of the Mekong Delta. The majority of the programmes were developed by agrochemical companies promoting products for pest and disease control in rice, vegetables and fruit. In addition, the extension videos made by the staff of Cantho University recommend the prophylactic use of acaricides, insecticides and fungicides.

The majority of farmers weeded by hand, and only about 30% used herbicides (Van Mele and Phen 1999). Herbicide use was best predicted by farmers reporting thrips as a pest problem and by those reporting the neighbour as a pesticide information source. Herbicides were also more frequently used in larger orchards. Often these richer farmers have been more exposed to technical information, hence their awareness of the existence of thrips. They also perceive an orchard without undergrowth as a clean, well-managed orchard.

Foliar fertilisers were mostly applied by farmers reporting mealybugs and aphids *Toxoptera aurantii* and *T. citricidus* (Homoptera: Aphididae) to be a problem, and by those reporting media as a pesticide information source. Seemingly, the promotion of foliar fertilisers goes hand in hand with the promotion of pesticides. Those who apply foliar fertilisers are generally chemical-intensive fruit growers who face more problems with secondary pests such as mealybugs.

3.4. Pesticide choice

The number of pesticide products applied was significantly higher in Tieu mandarin, and when farmers got advice from the media or staff from the university (table 6). Farmers keeping weaver ants in their orchard used fewer different products.

Pesticides are mostly promoted by involving famous singers of the traditional opera *Cai luong*, national athletes, beautiful women or farmers. The message is that when using pesticides, economic benefits are always guaranteed. The most widely used insecticides in Can Tho were methyl parathion (Methylparathion), monocrotophos (Azodrin) and methamidophos (Monitor), all of which have been banned (table 9), and α-cypermethrin (Cyper-Alpha, Fastac) (Van Mele and Cuc 2000). Nearly all the major pesticide products used in Can Tho province are distributed by the Cantho Pesticides Company. α-Cypermethrin, promoted by pesticide sellers and by the media (table 7), was mainly applied against the citrus leafminer.

Implementation of pesticide regulations is still weak and should be enforced. Farmers relying on the pesticide seller applied more of the banned product methyl parathion (table 7), mainly against aphids and mealybugs. Although the type of pesticides sold in shops was primarily based on farmers' demand (87%) and, second, on company promotion (56%) (table 8), surprisingly, none of the sellers mentioned that farmers still asked for these products. Despite this, in the beginning of 1998 about 15% of the citrus farmers reported that they still applied this product (Van Mele and Cuc 2000). Similarly, in 1998, several vegetable farmers in Can Tho province reported applying methyl parathion and carbofuran (Hai *et al.* 2000). It is possible that farmers bought large stocks of these products before they were banned in 1997 (methyl parathion) or June 1998 (monocrotophos and methamidophos), or that the products were still sold under the counter. It should also be noted that our last interviews took place in April 1998, just before the ban of latter two products.

Tieu mandarin farmers in Dong Thap most frequently applied methidathion (Supracide), fenpropathrin (Danitol), imidacloprid (Admire, Confidor) and sulphur (Microthiol, Kumulus) (Van Mele and Cuc 2000). Except for imidacloprid, the products were

Table 6. General linear model parameter estimates for the number of pesticide products purchased by citrus farmers (n=150), Mekong Delta, 1998

	Number of pesticides	
	B[1]	*p*
Media	1.92	<0.001
University	2.58	0.023
O. smaragdina	−1.78	0.001
Tieu mandarin	2.29	0.001
Mixed orchard	1.45	0.024
Lai Vung district	2.21	<0.001
Intercept	2.29	<0.001

[1]B, regression coefficient; *p*, probability.

Table 7. Odds ratios (p) of major pesticides used by citrus farmers who rely on different sources of pesticide advice, Mekong Delta, 1998 (n=150). **Bold** *indicates discriminating variables at p ⩽ 0.05 for individual models of information source*

	Own experience	Media	Pesticide seller	Extension officer	Neighbour
Insecticides/acaricides					
α-Cypermethrin	**2.68** (0.07)	**3.22** (0.01)	**2.75** (0.06)	0.77 (0.75)	0.85 (0.88)
Methyl parathion	2.13 (0.20)	1.37 (0.55)	**3.12** (0.07)	–[1]	0.54 (0.65)
Carbofuran	0.96 (0.95)	0.86 (0.82)	1.54 (0.57)	0.04 (0.35)	–
Propargite	1.55 (0.64)	0.84 (0.84)	8.82 (0.08)	0.36 (0.37)	**33.89** (0.02)
Fenpropathrin	2.89 (0.23)	0.38 (0.29)	0.12 (0.14)	**11.83** (0.01)	13.16 (0.07)
Sulphur	**0.18** (0.06)	2.34 (0.34)	0.06 (0.06)	**22.45** (0.01)	21.28 (0.09)
Hexythiazox	0.65 (0.67)	0.55 (0.57)	1.70 (0.75)	**0.04** (0.02)	0.06 (0.22)
Fenpyroximate	1.14 (0.89)	**8.98** (0.04)	1.44 (0.83)	0.29 (0.31)	–
Fungicides					
Zineb + Bordeaux	**5.28** (0.03)	0.86 (0.80)	–	5.31 (0.05)	0.27 (0.39)
Zineb	0.53 (0.38)	1.55 (0.50)	**0.11** (0.11)	0.44 (0.51)	**26.82** (0.00)
Carbendazim	0.76 (0.61)	**2.02** (0.18)	0.41 (0.29)	1.09 (0.91)	2.43 (0.43)
Kasugamycin + copper oxychloride	0.42 (0.18)	1.74 (0.37)	1.48 (0.64)	**3.38** (0.10)	0.14 (0.18)
Fosetyl aluminium	1.72 (0.40)	1.36 (0.63)	3.30 (0.21)	1.04 (0.97)	0.23 (0.27)

[1]Odds ratios could not be calculated because of insufficient data.

mainly used against mites. Because most farmers in Dong Thap applied methidathion and imidacloprid to target the citrus leafminer (Van Mele and van Lenteren 2002), no statistical differences between the sources of information could be observed. The frequent use of the above-mentioned pesticides, and especially of the most toxic ones such as methyl parathion, monocrotophos, methamidophos and methidathion, has a disastrous effect on weaver ants and other beneficial organisms, creating new insect pest and mite problems. Pesticide toxicity data are available for several major predators and parasitoids (Biobest 1998, Anon. 1999), but not for weaver ants.

The media actively promoted the acaricide fenpyroximate (Ortus) (table 7). Pesticide sellers promoted the acaricide propargite (Comite), which gained further popularity by farmer-to-farmer propaganda. Fenpropathrin against mites and thrips, and sulphur (Microthiol) against mites were strongly advertised by the extension service. These were the cheapest products to control mites (table 9). Only propargite has been reported to have low toxicity for most natural enemies (Flint 1991), but it is more expensive than the other acaricides available on the market. Microthiol was produced by Cantho University in 1996–97 and strongly promoted against mites by the extension staff and by word of mouth. It was sold at one-third of the market price of Kumulus, another commercial sulphur formulation. By now, Microthiol is also produced by a commercial company and sold as expensively as Kumulus.

About 45% of all Tieu mandarin farmers used kasugamycin + copper oxychloride (Kasuran). The product was mainly promoted by the extension and media against citrus canker, *Xanthomonas campestris* pv. *citri* (Hasse) Dye. Fosetyl aluminium (Aliette), applied by about 40% of the Tieu mandarin farmers, was the main product promoted by the pesticide sellers for controlling citrus canker (42%) and root rot (23%). The fungicide Zineb + Bordeaux (Copper Zinc) is produced by Cantho University and is strongly promoted by the Extension Service. About 10% of the farmers used it, some applying it against the citrus greening disease that is sometimes confused with zinc deficiency.

Table 8. Criteria on which pesticide sellers select the products they sell in their shop, Mekong Delta, 1998–99

	Rank of importance[1]			
	1	2	3	4
Farmers ask specific product	86.5	3.8	1.9	0.0
Company promotes product	9.6	55.8	9.6	0.0
TV advertisement	0.0	11.5	42.3	0.0
Radio advertisement	0.0	0.0	7.7	17.3

[1]1, Most important; 2, second most important, etc.

3.5. *Pesticide use pattern*

More than 50% of the sweet orange farmers did not apply fungicides at all, whereas nearly all Tieu mandarin farmers did (Van Mele and Cuc 2000). Tieu mandarin is more susceptible to root rot than sweet orange. Besides, the cosmetic appearance of the fruit is very important, because these mandarins are offered to the ancestors during the Vietnamese New Year. With the exception of Microthiol, all the popular products used by Tieu mandarin farmers were more expensive than the ones used by sweet orange farmers (table 9). Fruit damage by mites or the brown spot disease reduces its market value and, hence, these pests are main targets. These targets were more important for farmers relying on extension (table 4). Farmers who relied on extension sprayed 43% of their target sprays against mites compared with 24% by those who had no advice from the extension service. Extension being most important in Dong Thap, Tieu mandarin farmers in this province spent twice as much on fungicides compared with those in Can Tho province ($n = 79$, Mann–Whitney U-test $= 86.0$, $p < 0.001$).

Analysing the pesticide use pattern of that group of farmers who applied insecticides or fungicides, farmers relying on media sprayed insecticides more frequently, and those getting advice from the extension applied both insecticide and fungicide sprays more frequently (table 10). Farmers relying on both extension and media applied 1.26 (4.18 + 3.10 − 8.54) insecticide sprays less compared with those who do not get advice from media or extension at all. Those farmers relying on the extension officer sprayed insecticides 8.4 more times (0.45 + 7.95) per increase

Table 9. Prices (US\$/100 cm^3)[1] of some common insecticides used by citrus farmers in the Mekong Delta

Insecticides/acaricides	Trade name	WHO Class[2]	Application rates (g ai/ha^{-1})	1997	1998
Monocrotophos	Azodrin	Ib	500	0.37	banned
Methyl parathion	Methyl parathion	Ia	500	banned	banned
Methamidophos	Monitor	Ib	700	0.37	banned
Methidathion	Supracide	Ib	400	1.16	1.11
Fenobucarb (BPMC)	Bassa	II	500	0.26	0.25
Cypermethrin	Ustaad, Sherpa, Cymbush	II	250	1.04	1.07
Alpha-cypermethrin	Cyper-alpha, Vifast, Fastac	II	25	0.72	0.74
Fenpropathrin	Danitol	II	10	0.92	0.95
Imadacloprid	Admire, Confidor	II	5	3.04	2.92
Sulphur (100 g)	Kumulus	IV	2000	1.20	1.11
Sulphur (100 g)	Microthiol	IV	2000	0.34	0.32
Propargite	Comite	III	750	2.31	2.14
Fenpyroximate	Ortus	–	75	1.60	1.48
Hexythiazox	Nissorun	IV	40	2.02	1.87

[1]US\$1=VND 12 500 in 1997 and VND 13 500 in 1998. [2]Ia, Extremely hazardous; Ib, highly hazardous; III, slightly hazardous; IV, unlikely to present acute hazard in normal use; –, unclassified.

of unit land (1 ha). Farmers with larger orchards typically have less off-farm employment activities, increasing their risk aversion, which probably explains their higher pesticide use (Rabb *et al.* 1972). Another likely reason is that these farmers often rely on external labour and hence choose for the 'easy' chemical option.

3.6. Biological control with Oecophylla smaragdina

Most insecticides currently applied are detrimental to *O. smaragdina*. Preliminary results indicate that fungicides and foliar fertilisers reduce the ant foraging behaviour, decreasing the efficiency of this biological control agent (Nguyen Thi Thu Cuc, unpublished data). *Oecophylla smaragdina* was abundant in only 25% of the Tieu mandarin orchards mainly because the high pesticide pressure, and in about 75% of the other citrus orchards (Van Mele and Cuc 2000). For each of these two groups of orchards, logistic regression models were built for each information source based on all production characteristics. All non-significant factors were eliminated and only significant factors are discussed.

For citrus species other than Tieu mandarin ($n = 72$), farmers relying on the media for pesticide advice were best discriminated by the criteria ants (OR = 0.26, $p = 0.027$) and Can Tho city (OR = 3.55, $p = 0.025$), whereas those relying on extension were best discriminated by ants (OR = 0.26, $p = 0.077$). An OR < 1 indicated that those farmers practising weaver ant husbandry were less influenced by media and extension (figure 2). The presence of ants was not important for farmers' choice of other information sources. It could be postulated that because media or extension significantly stimulate chemical pest control (table 10), these information sources have a negative effect on the traditional practice of weaver ant husbandry.

For the more intensively cropped Tieu mandarin, a slightly different picture emerges. Tieu mandarin farmers ($n = 78$) with *O. smaragdina* relied more on the media for pesticide advice than those farmers without ants (OR = 5.03, $p = 0.007$), but nevertheless used less pesticides and sprayed less frequently than those farmers without ants (Van Mele and Cuc 2000). Especially those Tieu mandarin farmers with a higher education level received more advice from the extension staff (OR = 1.23, $p = 0.018$). Extension staff sometimes contact farmers through 'advanced farmer clubs', whose members often have a high education level and a strong social position.

4. Discussion

Many developing countries still ignore an IPM approach and rely on pesticides for a quick solution to deal with pest problems. This has often been aided by commercial advertisements by chemical companies and by the pesticide sellers, who often have more influence on farmers than extension officers do (Sharma 1998). In the Mekong Delta, media was the most important information source for about 40% of the citrus farmers, a similar percentage to that of mango farmers (Van Mele *et al.* 2001a), but it was mentioned by $< 10\%$ of the rice farmers (Chung and Dung 1996). Non-IPM rice farmers relied mainly on the pesticide seller and neighbours when purchasing a product, whereas IPM farmers relied more on the extension staff (Chung and Dung 1996). Although in citrus the pesticide seller was mentioned by about 20% of the farmers, which was slightly more than the extension officer, the latter had a more significant impact on pest perception and management. The increased knowledge of difficult-to-observe pests acquired through extension activities coincided with increased use of agrochemicals, especially of acaricides and fungicides. Mite damage was limited to non-existent in orchards where farmers do not use pesticides. Recent studies also indicated that parasitation rates of citrus leafminer was higher in trees with ants (Hanssen 2001), indicating the complementary roles predators and parasitoids play in regulating the orchard pest complex. Farmers are clearly trapped in a vicious circle: pesticide companies define a pest problem, which is disseminated by extension and the media. This leads to farmers developing the idea that they have pest problems that in fact they might not have — or not to a degree to justify the frequency and toxicity of chemical use. Farmers in turn then exercize demand over the pesticide sellers, to deal with the problems they are persuaded they have, so that pesticide companies can then claim to be meeting felt needs. A well-developed and coordinated programme on farmer participatory training and research that focuses on experiential learning and field observations could break this vicious circle by enhancing farmers' perceptions of pests, their ecological

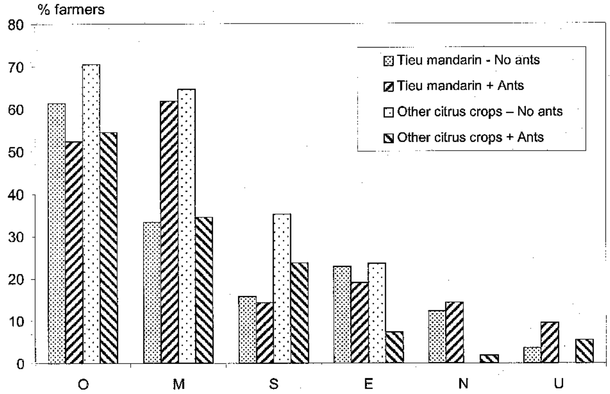

Figure 2. Sources of information influencing farmers' decision-making related to pesticide use in different citrus crops with and without the ant Oecophylla smaragdina. *O, own experience; M, media; S, pesticide seller; E, extension officer; N, neighbour.*

Table 10. General linear model parameter estimates for the number of pesticide sprays applied by those citrus farmers using pesticides, Mekong Delta, 1998

	No. of insecticide sprays (n=83)		No. of fungicide sprays (n=58)	
	B^1	p	B	p
Own experience	4.67	0.001	–	–
Extension	4.18	0.128	3.28	0.065
Media	3.10	0.041	–	–
Extension * Media	−8.54	0.004	–	–
Extension * Area	7.95	0.018	–	–
Area	0.45	0.801	–	–
Omon district	−8.55	<0.001	–	–
Can Tho city	−11.04	<0.001	–	–
Lai Vung district	–	–	6.13	<0.001
Intercept	5.95	0.001	3.51	0.008

[1]B, regression coefficient; p, probability.

causalities and non-chemical alternative management options (Braun *et al.* 2000, CABI 2001, Nelson *et al.* 2001).

Some of the constraints in promoting IPM in developing countries have been described as ‘farmer individualism’ and the linking of ‘progressive farmer’ status with the expenses of chemical inputs (Sharma 1998). Both constraints are prevalent in the Mekong Delta. Competition between fruit farmers is strong and this characteristic should be used positively in the development of IPM rather than be looked at as a constraint. By the end of 1999, one Tieu mandarin farmer received an award from a local government for producing the highest quality fruit without using pesticides and by practising weaver ant husbandry. The event was broadcast on television. Local initiatives like this could be further stimulated and preferably be combined with institutional and scientific support for biological control. Because farmers practising weaver ant husbandry have no forum or platform to exchange ideas, the establishment of ‘weaver ant clubs’ should receive priority. Developing platforms for farmer decision-making has been described as an interesting area of extension research (Röling and van de Fliert 1994). The second constraint might be even more pronounced for farmers growing high-value cash crops such as Tieu mandarin than for farmers cultivating subsistence crops such as rice. In the ’advanced farmer clubs’, chemical pest control is indeed often high on the agenda, and in some cases club meetings have been organized by pesticide companies.

Since media and extension were major sources influencing farmers’ pest management practices generally leading to increased use of agrochemicals and potentially reducing the use of the ant *O. smaragdina* as a biological control agent, the government has a very important role to play in promoting sustainable agriculture. One way could be through regulating information provision. Pesticide labels and advertisements should, for instance, indicate the product’s toxicity towards both people and weaver ants. Likewise, ant compatible technologies should be promoted both at the policy and RD implementation level. Highly selective petroleum spray oils have been registered since 2000 and were almost immediately used against citrus leafminer by farmers knowledgeable about weaver ants, indicating the openness of farmers in the use of environmentally friendly alternatives if they are made available (Van Mele *et al.* 2001b). The present research also indicates the importance of the media in pest management. Ideally, farmer participatory research and training programmes should be complemented by a well-developed mass media campaign promoting the use of this endemic natural enemy.

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References

ADESINA, A. A., JOHNSON, D. E. and HEINRICHS, E. A., 1994. Rice pests in the Ivory Coast, West Africa: farmers’ perceptions and management strategies. *International Journal of Pest Management*, **40**, 293–299.

AGRESTI, A., 1990. *Categorical Data Analysis* (New York: Wiley).

ALTIERI, M. A., 1993. Ethnoscience and biodiversity: key elements in the design of sustainable pest management systems for small farmers in developing countries. *Agriculture, Ecosystems and Environment*, **46**, 257–272.

ANON., 1999. Database on pesticides and the environment Economic and Social Commission for Asia and the Pacific (ESCAP), Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Commission of the European Union (EU) [http://www.fadinap.com/pesticide].

ATTEH, O. D., 1984. Nigerian farmers’ perception of pests and pesticides. *Insect Science and Its Application*, **5**, 213–220.

BIOBEST, 1998. *Side Effects of Pesticides on Bumblebees and Beneficials* (Westerlo: Biobest NV).

BRAUN, A. R., THIELE, G. and FERNANDEZ, M., 2000. *Farmer Field Schools and Local Agricultural Research Committees: Complementary Platforms for Integrated Decision-making in Sustainable Agriculture*. Agricultural Research and Extension Network Paper No. 105 (London: Overseas Development Institute).

BURLEIGH, J. R., VINGNANAKULASINGHAM, V., LALITH, W. R. B. and GONAPINUWALA, S., 1998. Pattern of pesticide use and pesticide efficacy among chilli growers in the dry zone of NE Sri Lanka (System B): perception vs reality. *Agriculture, Ecosystems and Environment*, **70**, 49–60.

CABI (CENTER FOR AGRICULTURE AND BIOLOGICAL SCIENCES INTERNATIONAL), 2001. *Learning to Cut the Chemicals in Cotton: Case Studies and Exercises in Farmer Focused Cotton IPM from Around the World* (London: Pan), pp. 95.

CHUNG, D. K. and DUNG, K. T., 1996. *Pest Management in Rice Production in Vietnam: A Socioeconomic Assessment* (Hanoi: Hanoi Agricultural University).

DANG, N. P., 1997. Le rôle de la vulgarisation dans la promotion de la culture des arbres fruitiers dans le Delta du Mékong. Mémoire diplôme du Master VOPA, Centre National d’Études Agronomique des Régions Chaudes, Montpellier.

DEBRAH, S. K., DEFOER, T. and BENGALY, M., 1998. Integrating farmers’ knowledge, attitude and practices in the development of sustainable *Striga* control interventions in southern Mali. *Netherlands Journal of Agricultural Science*, **46**, 65–75.

ESCALADA, M. M., and HEONG, K. L., 1993. Communication and implementation of change in crop protection. In D. J. Chadwick and J. Marsh (eds), *Crop Protection and Sustainable Agriculture* (Chichester: Wiley), pp. 191–207.

FLINT, M. F., 1991. *Integrated Pest Management for Citrus*, 2nd edn (California: University of California Press).

FUJISAKA, S., 1992. *Will Farmer Participatory Research Survive in the International Agricultural Research Centres?* Gatekeeper Series No. SA44 (London: International Institute for Environment and Development), pp. 3–14.

HAI, T. V., BA, T. T., SON, P. K., HAI, T. T., NGA, N. T. T., DUNG, H. A. and TRI, T. V., 2000. Survey of cultivation practices, pesticide use and pest control in vegetables in Can Tho, Soc Trang and An Giang province in 1998. Paper presented at the First Joint Workshop on Environmental Conservation and Sustainable Agriculture, Cantho University, 19–21 January 2000. JICA-CTU Project for the Improvement of Environmental Education in Agricultural Sciences. [in Vietnamese]

HANSSEN, I., 2001. Geïntegreerde bestrijding in citrusteelt in de Mekong Delta, Vietnam: rol van de Aziatische wevermier Oecophylla smaragdina. MSc thesis, Catholic University Leuven, Leuven.

HEONG, K. L. and ESCALADA, M. M., 1997. *Pest Management of Rice Farmers in Asia* (Manila: International Rice Research Institute).

HEONG, K. L., ESCALADA, M. M., HUA, N. H. and MAI, V., 1998. Use of Communication media in changing rice farmers’ pest management in the Mekong Delta, Vietnam. *Crop Protection*, **17**, 413–425.

KENMORE, P. E., 1991. *Indonesia’s Integrated Pest Management — A Model for Asia*. FAO Rice IPC Programme (Manila: FAO).

KENMORE, P. E., LITSINGER, J. A., BANDONG, J. P., SANTIAGO, A. C. and SALAC, M. M., 1987. Philippine rice farmers and insecticides: thirty years of growing dependency and new options for change. In J. Tait and B. Napompeth (eds), *Management of Pests and Pesticides: Farmers' Perceptions and Practices* (Boulder: Westview), pp. 98–108.

MORSE, S. and BUHLER, W., 1997. *Integrated Pest Management Ideals and Realities in Developing Countries* (London: Lynne Riener).

MUMFORD, J. D. and NORTON, G. A., 1993. Survey and knowledge acquisition techniques. In G. A. Norton and J. D. Mumford (eds), *Decision Tools for Pest Management* (Wallingford: CAB International), pp. 79–88.

NELSON, R., ORREGO, R., ORTIZ, O., TENORIO, J., MUNDT, C., FREDRIX, M. and VIEN, N. V., 2001. Working with resource-poor farmers to manage plant diseases. *Plant Disease*, **85**, 684–695.

NORTON, G. A. and MUMFORD, J. D., 1982. Information gaps in pest management. *Proceedings of the International Conference on Plant Protection in the Tropics*, pp. 589–597.

RABB, R. L., STINNER, R. E. and CARLSON, G. A., 1972. Ecological principles as a basis for pest management in the agroecosystem. In *Concepts of Pest Management*. Lecture Notes (Raleigh: North Carolina State University), pp. 19–44.

RÖLING, N. and VAN DE FLIERT, E., 1994. Transforming extension for sustainable agriculture: the case of integrated pest management in rice in Indonesia. *Agriculture and Human Values*, **11**, 96–108.

SHARMA, M. C., 1998. Integrated pest management in developing countries. *RIS Biotechnology and Development Review*, **2**, 9–18.

VAN DE FLIERT, E., 1993. *Integrated Pest Management Farmer Field Schools Generate Sustainable Practices. A Case Study in Central Java Evaluating IPM Training*. Wageningen Agricultural University Papers 93-3.

VAN HUIS, A. and MEERMAN, F., 1997. Can we make IPM work for resource-poor farmers in sub-Saharan Africa? *International Journal of Pest Management*, **43**, 313–320.

VAN MELE, P., 2000. Evaluating farmers' knowledge, perceptions and practices: a case study of pest management by fruit farmers in the Mekong Delta, Vietnam. PhD thesis, Wageningen University, Wageningen, The Netherlands.

VAN MELE, P. and CUC, N. T. T., 2000. Evolution and status of *Oecophylla smaragdina* (Fabricius) as a pest control agent in citrus in the Mekong Delta, Vietnam. *International Journal of Pest Management*, **46**, 295–301.

VAN MELE, P., CUC, N. T. T. and VAN HUIS, A., 2001a. Farmers' knowledge, perceptions and practices in mango pest management in the Mekong Delta, Vietnam. *International Journal of Pest Management*, **47**, 7–16.

VAN MELE, P., CUC, N. T. T. and VAN HUIS, A., 2002. Direct and indirect influences of the weaver ant Oecophylle sinaragdina on citrus farmers' pest perceptions and management practices in the Mekong Delta, Vietnam. *International Journal of Pest Management*, **46**, (in press).

VAN MELE, P., MAI, V., CHIEN, H. V. and CUC, N. T. T. (eds), 2001b. *Weaver Ants: A Golden Opportunity. Proceedings of Citrus Farmer Workshop*, February 2001, Tien Giang, Vietnam (Wallingford: CABI Bioscience).

VAN MELE, P. and PHEN, T. V., 1999. Utilisation and management of orchard ground cover in the Mekong Delta, Vietnam. *Proceedings of the 17th Asian-Pacific Weed Science Society Conference*, Bangkok, 22–27 November 1999, pp. 296–302.

VAN MELE, P. and VAN LENTEREN, J. C., 2002. Survey of current crop management practices in a mixed-rice field landscape, Mekong Delta, Vietnam — potential of habitat manipulation for improved control of citrus leafminer and citrus red mite. *Agriculture, Ecosystems and Environment*, **88**, 35–48.