Cambodia-IRRI-Australia Project
Baseline Survey Report No. 6

FARMERS' PEST MANAGEMENT AND RICE PRODUCTION PRACTICES IN CAMBODIAN LOWLAND RICE

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INTRODUCTION

Most Cambodians are lowland rice farmers. Although the most important crop protection issues in Cambodia are those of lowland rice, the key rice pests, i.e., pests which regularly constraint yields, have not yet been determined for Cambodia. CIAP is using this survey to document which lowland rice pests the farmers report, and to target our research on the effects of those pests on yields.

There are no laws or regulations dealing with pesticides[1] in Cambodia. Anyone can purchase and use pesticides from Thailand and Vietnam, without restrictions (Pisani 1996). To evaluate the need for pesticide regulations the Cambodian government requires data on the extent of pesticide use. Through this survey we are providing the government this data.

The CIAP IPM Program survey of lowland rice farmers is the largest pest management survey undertaken to date in Cambodia. The survey was conducted to determine:

1. Pest management practices of lowland rice farmers;
2. Attitudes of lowland rice farmers toward pests, and pesticides;
3. What farmers would like to know about pest management;
4. Farmer knowledge of the rice ecosystem.

CIAP uses this information to :

1. Solve pest problems that farmers consider the most pressing;
2. Evaluate farmer practices scientifically;
3. Advise farmers and the organizations that assist farmers;
3. Identify dangerous or ineffective pest management practices;
4. Conduct research to improve upon dangerous or ineffective practices;
5. Assist the in the development of training courses for rice farmers;
6. Address popular misconceptions.

SURVEY SITE

From June 1995 to April 1996, 1265 families in 154 villages were interviewed by the CIAP IPM Program about their rice production practices with emphasis on agrochemical inputs and pest management (Table 1). The survey was conducted in 10 provinces: Battambang, Kampong Cham, Kampong Chhnang, Kampong Speu, Kandal, Prey Veng, Pursat, Siem Reap, Svay Rieng, and Takeo (Figure 1). These provinces represent 76% of the Cambodian lowland rice area (Javier 1996). Over 100 people were interviewed in each province. Survey sites were chosen on the basis of accessibility, security, and lowland rice production. Of those farmers

[1] A pesticide is any substance used for controlling, preventing, destroying, repelling, or mitigating any pest. Types of pesticides include fungicides, herbicides, insecticides, and rodenticides (Ware 1994).

interviewed, 1223 farmers grew rice in the wet season (WS) and 304 grew rice in the dry season (DS)

Table 1. Population included in survey.

Province	No. of districts	No. of communes	No. of villages	No. of families	No. wet season farmers	No. dry season farmers
Battambang	5	5	7	119	119	0
Kampong Cham	3	8	20	100	100	8
Kampong Chhnang	4	9	22	126	125	31
Kampong Speu	3	7	11	104	104	42
Kandal	2	7	14	117	108	23
Prey Veng	4	10	14	121	109	41
Pursat	4	8	13	115	115	0
Siem Reap	3	6	15	105	105	71
Svay Rieng	5	7	14	239	231	36
Takeo	5	14	24	119	107	52
TOTAL	39	81	154	1265	1223	304

METHODS

We collected data on farmers' pest management practices through structured personal interviews, using a questionnaire specifically designed for the purpose. The first version of the questionnaire was based on an IRRI survey conducted in Vietnam to test the effects of a No-Early-Spray Campaign (Heong *et al.* 1994; Rapusas *et al.* 1994). We revised the survey to suit project needs. The survey was revised and tested five times; on 25 different farmers each time. In its final form the survey consisted of 70 questions. Originally we asked farmers to name the most common pests, but we found that there was little agreement on local names of arthropods, even within the same village. We therefore created a poster of photographs and drawings of common rice arthropods, weeds, and diseases. Pests and natural enemies were displayed on the poster in a random mixture. Farmers were asked to point to the pests on the poster that cause problems in their fields, and then asked if there were additional pests not shown on the poster. The questionnaire was originally written in English and then translated into Khmer. The survey was conducted by Cambodians who were trained in survey techniques and in using the questionnaire.

There are no lists of the residents of each village, making random selection difficult. In each village a group of 2 to 5 interviewers conducted the survey. A total of 14 interviewers conducted the entire survey. Interviewers were free to chose any farm they wished to conduct the survey. A given farm could only be represented once in the survey. While this was not a truly random sample, but a haphazard sample, there is no indication that the survey results represent any bias on the part of interviewers in terms of farmer selection. Given that parametric tests are robust, we assumed a normal distribution and a random sample for the purpose of data analysis. The survey data was analyzed with the Microsoft Excel® software program (Microsoft Corporation 1993). Averages were compared by t-tests. Frequency associations were measured by chi-square tests.

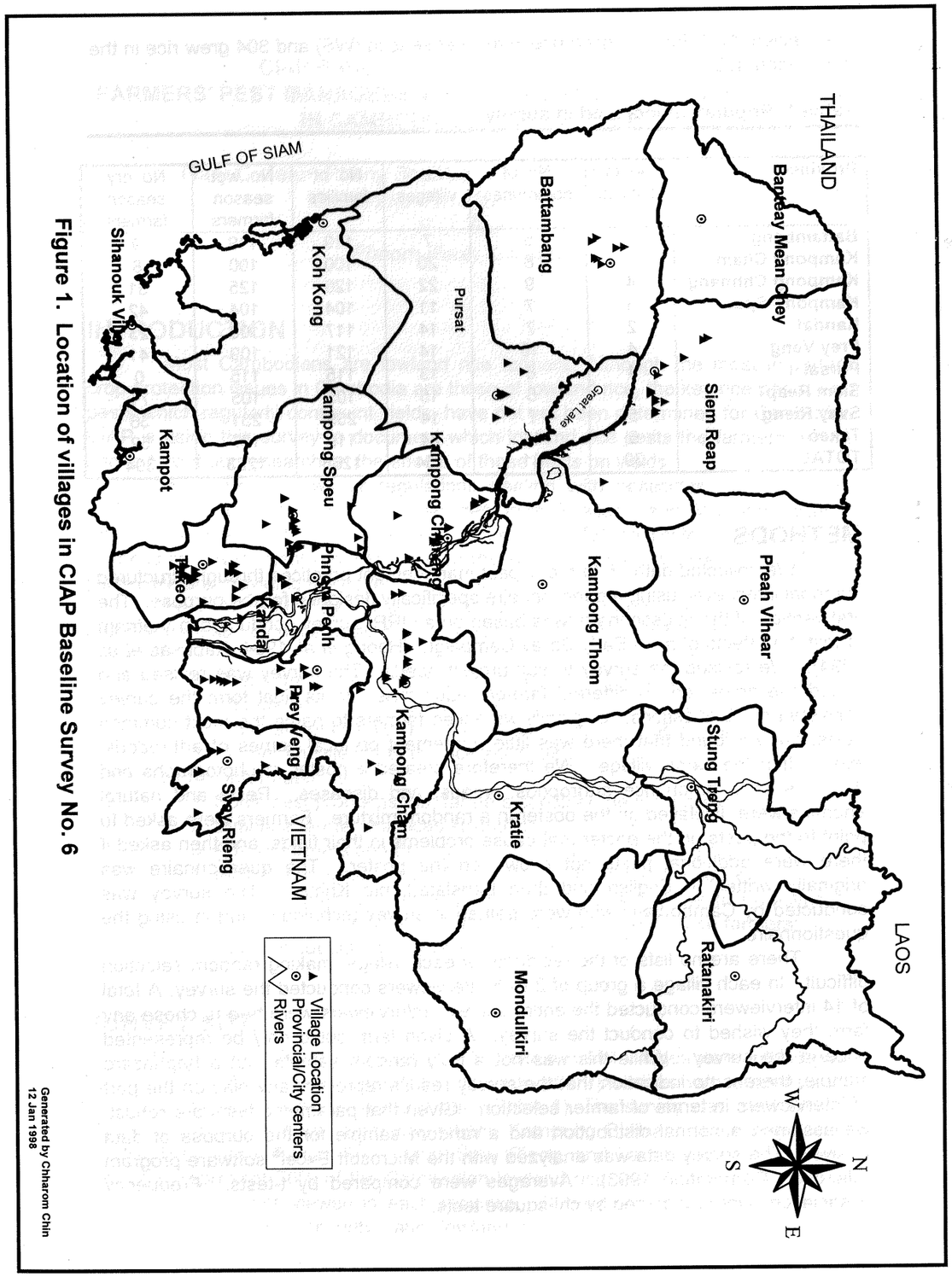

Figure 1. Location of villages in CIAP Baseline Survey No. 6

RESULTS & DISCUSSION

Farmer profile

In this survey 57% of the farmers interviewed were male and 43% were female. The gender percentages should not be taken to indicate the sex ratio of rice farmers, since no attempt was made to record the number of men and women in each household. Farmers ranged in age from 17 to 82 years with an average age of 42.6 years. Respondents had 0-13 years of education with an average of 3.7 years. Most of the respondents spent the greater part of their lives as rice farmers. Experience in rice farming ranged from 1 to 64 years with an average of 22.7 years. The farmer profile for each province is presented in Table 2.

Table 2. Farmer profile for each province surveyed.

Province	Average age (in years)	Average education (in years)	Average experience (in years)	% Females
Battambang	43.4	3.4	22.9	43.7
Kampong Cham	43.8	4.4	24.3	51.0
Kampong Chhnang	44.2	4.2	24.7	49.2
Kampong Speu	46.9	3.0	26.5	56.7
Kandal	42.3	3.3	21.2	43.6
Prey Veng	42.4	3.9	24.2	34.7
Pursat	42.2	3.7	21.5	38.3
Siem Reap	40.0	2.9	18.8	40.0
Svay Rieng	41.5	4.0	22.4	38.9
Takeo	42.6	4.4	18.9	34.5
Overall average	42.6	3.7	22.7	43.0

Since the 1993 elections, land tenure remains an unresolved issue in Cambodia; nonetheless 99% of WS farmers and 100% of DS farmers claimed that they owned their largest fields.

Farm profile

Farmers were asked the area of their largest fields and how that field was watered. Based on that information, 16% of land was irrigated by pump and 1% was irrigated by hand using buckets. The percentage of land irrigated by pump varies greatly from province to province. None of the farmers interviewed in Battambang irrigated their largest fields. Takeo had the highest percentage of land irrigated by pump (Table 3).

Farmers were asked to describe the color and texture of the soil in their largest fields. All together, they named 41 different combinations of soil color and texture. The highest percentage of farmers reporting a single soil type, was 17% for red sandy soil (Table 4).

Table 3. Percentage of land irrigated by pump.

Province	% Pump
Battambang	0
Kampong Cham	15
Kampong Chhnang	10
Kampong Speu	42
Kandal	17
Prey Veng	35
Pursat	3
Siem Reap	2
Svay Rieng	15
Takeo	49
Overall Percentage[1]	16

[1] The percentage of all farmers surveyed, not an average of the provincial percentages.

Table 4. Percentage of farmers reporting different soil types in their largest fields.

Soil Type	Percent of Farmers Reporting
Red sandy soil	17
Yellow sandy soil	13
Black loam	13
Gray clay	7
Gray loam	6
Gray sand	6
Other[1]	39

[1] Less than 6% of farmers named any one of the 35 additional types of soil reported

Only 9% of farmers followed rice with a different crop; 5% of farmers planted another crop of rice following harvest; and 86% left the field fallow following harvest.

Wet season

Most farmers, 92%, transplanted their WS rice; only 11% practiced direct seeding. On the average, seedlings were 49 days old at transplanting and farmers planted 4 to 5 seedlings per hill. Hills were planted an average of 22 cm apart. Families growing WS rice farmed 1 to 14 fields; 3 fields on the average. The largest fields ranged from 0.05 to 7.0 ha, with an average size of 0.6 ha. Among WS farmers that transplanted rice, the average area transplanted was 1.0 ha. Of the WS farmers practicing direct seeding, the average area direct seeded was 2.2 ha. Though all the WS fields in this survey were lowland, 16% of WS farmers described their fields as low-lying, 71% as medium, and 13% as high. Approximately 77% of WS fields were never flooded by river water, 22% were flooded once a year, and 1% more than once a year. About 8% of wet season farmers used irrigation pumps.

WS farmers reported growing 40 different varieties of rice. Most farmers grew traditional varieties. The most popular traditional variety was Neang Minh, a late duration rice grown by 19% of the WS farmers on 29% of the WS land. Only 1.2% of WS farmers grew IR varieties, representing an estimated 0.9% of the national area transplanted to rice. Most WS farmers, produce their own seed (Table 5) though less than 1% put aside land specifically for seed multiplication.

Dry season

Most farmers, 72%, transplanted their DS rice, while 32% direct seeded. Seedlings were transplanted at an average age of 25 days at 4 to 5 seedlings per hill. The distance between hills averaged 16 cm. DS families farmed 1 to 7 fields, with 2 fields per family on the average. The largest DS fields ranged from 0.05 to 3.5 ha., with an average size of 0.5 ha. DS farms had an average of 0.7 ha transplanted rice (excluding households without transplanted fields); and an average of 0.8 ha of direct seeded rice (excluding households without direct-seeded fields). While all the fields in this survey were lowland, 24% of DS farmers described their fields as low-lying, 67% as medium, and 10% as high. Approximately 92% of DS fields flooded with river water once a year, while the remainder were never flooded by river water. Irrigation pumps were used by 58% of dry season farmers. Only 10% of DS farmers reported growing two DS crops per year on the same piece of land; representing 14% of the DS land described in this survey.

Most DS farmers, 82%, grew IR varieties, representing an estimated 92% of the national DS rice area. The most popular IR variety in the dry season was IR66, grown by 54% of the DS farmers, representing 60% of the DS land in this survey (but 11% of all lowland rice in the survey area). Over half the DS farmers produced their own seed (Table 5), but less than 1% put aside land specifically for seed multiplication.

Table 5. Percentage of wet and dry season farmers receiving seeds from different sources.

Source of Seeds	Wet Season	Dry Season
Self	81.8	53.5
Neighbor	17.8	38.6
Government	0.3	6.9

Fertilizer Use

In both seasons, more farmers used inorganic fertilizers than organic fertilizers (Table 6).

Table 6. Percentage of all farmers using fertilizers in the wet and dry seasons.

Season	% using fertilizer	% using organic	% using inorganic
Wet	82.5	45	73
Dry	70.4	15	70

Use of the compound inorganic fertilizer 16-20-0 was generally low, except in Battambang. In both seasons, Siem Reap had the lowest percentage of fertilizer users for each type of fertilizer. A greater percentage of WS farmers than DS farmers used each type of fertilizer (Tables 7 and 8). In both seasons, the greatest percentage of farmers applying manure was at the seedling stage. The first manure application, before seeding, is generally worked into the soil by harrowing. Once the rice has emerged, manure is simply throw onto the field. Over half of all DS farmers and over a third of WS farmers apply urea at the tillering stage (Tables 9 and 10). The average dry season yield for fertilizer users was 2.9 t/ha; and 1.9 t/ha for non-users. In the WS, fertilizer users averaged 1.4 t/ha, while non-users averaged 1.0 t/ha. Farmers using fertilizers had significantly higher yields in each season (two-tailed t-test: dry season $p < 0.0001$, wet season $p < 0.0001$).

Table 7. Percentage of wet season farmers using manure, urea, DAP and 16-20-0 in each province surveyed.

Province	Manure	Urea	DAP	16-20-0
Battambang	5.0	25.2	10.1	49.6
Kampong Cham	76.0	41.0	45.0	0.0
Kampong Chhnang	71.2	69.6	44.8	0.0
Kampong Speu	76.0	73.1	67.3	0.0
Kandal	19.4	75.9	75.0	0.0
Prey Veng	92.7	81.7	56.0	0.0
Pursat	2.6	36.5	45.2	22.4
Siem Reap	1.0	4.8	7.6	0.0
Svay Rieng	42.4	80.1	87.0	0.9
Takeo	68.2	71.0	41.1	0.0
All wet season farmers	44.8	58.3	51.6	7.2

Table 8. Percentage of dry season farmers using manure, urea, DAP and 16-20-0 in each province surveyed.

Province	Manure	Urea	DAP	16-20-0
Kampong Cham	12.5	87.5	12.5	0.0
Kampong Chhnang	9.7	71.0	25.8	3.2
Kampong Speu	64.3	100	90.5	0.0
Kandal	4.3	87.0	52.2	0.0
Prey Veng	29.3	90.2	24.4	0.0
Siem Reap	0.0	2.8	1.4	0.0
Svay Rieng	0.0	88.9	88.9	2.8
Takeo	3.8	84.6	32.7	0.0
All dry season farmers	15.4	33.8	39.3	1.0

Table 9. Wet Season fertilizer use in Cambodian lowland rice at each stage. 1223 farmers surveyed.

Crop Stage[1]	Type of fertilizer	% wet season farmers applying fertilizer	Average amount applied in kg/ha (excluding non-users)	Standard Deviation
Seedling	Manure	32.6	1628.0	1530.62
	Urea	17.2	16.8	18.76
	DAP	2.4	34.0	28.92
	16-20-0	2.5	49.5	19.62
Basal	Manure	17.6	1860.7	1672.56
	Urea	8.1	37.0	27.21
	DAP	20.4	54.3	28.24
	16-20-0	0.0	0.0	0.00
Tillering	Manure	5.2	2174.0	2402.58
	Urea	35.9	44.4	26.62
	DAP	33.2	50.2	26.94
	16-20-0	5.2	51.4	26.84
Booting	Manure	0.1	800.0	0.00
	Urea	22.9	46.9	27.35
	DAP	6.7	41.4	23.01
	16-20-0	1.0	51.7	30.80
Wet S. Mean	All types	82.5	492.4	1143.11

[1] Less than 1% of farmers applied fertilizer beyond the booting stage.

Table 10. Dry Season fertilizer use in Cambodian lowland rice at each stage. 304 farmers surveyed.

Crop Stage[1]	Type of fertilizer	% dry season farmers applying fertilizer	Average amount applied in kg/ha (excluding non-users)	Standard Deviation
Seedling	Manure	13.5	1387.6	921.69
	Urea	20.4	24.4	19.20
	DAP 18-46-0	2.3	67.0	26.07
	NPK 16-20-0	0.0	0.0	0.00
Basal	Manure	5.6	2473.8	2242.19
	Urea	10.5	53.0	31.98
	DAP 18-46-0	15.5	70.2	27.63
	NPK 16-20-0	0.7	67.9	0.00
Tillering	Manure	0.7	976.7	1287.02
	Urea	52.6	64.0	40.56
	DAP 18-46-0	26.3	74.4	46.83
	NPK 16-20-0	0.0	0.0	0.00
Booting	Manure	0.0	0.0	0.00
	Urea	32.2	57.2	37.62
	DAP 18-46-0	10.5	60.3	30.89
	NPK 16-20-0	0.0	0.0	0.00
Dry S. Mean	All types	70.4	224.9	683.07

[1] Less than 3% of farmers applied fertilizer beyond the booting stage.

Rice yields and varieties

The overall average reported yield was 1.5 t/ha, including farmers with zero yields due to floods or drought. The average yield in the DS was 2.5 t/ha, and in the WS was 1.3 t/ha. Average DS rice yields exceeded average WS rice yields in every province surveyed (Table 11).

Table 11. Average lowland rice yields (t/ha) for the wet and dry seasons.

Province	Wet Season	Dry Season
Battambang	1.67	No data
Kampong Cham	1.82	4.54
Kampong Chhnang	2.07	2.72
Kampong Speu	2.22	3.08
Kandal	1.30	2.42
Prey Veng	0.58	2.83
Pursat	1.46	No data
Siem Reap	0.59	1.14
Svay Rieng	0.67	1.97
Takeo	1.34	3.44
Overall Average	1.31	2.48

Combining wet and dry season data, we find that farmers growing IR varieties had an average yield of 2.4 t/ha, while those growing other varieties had an average yield of 1.3 t/ha. IR varieties were grown on 14% of the rice growing area described in the survey. About 93% of the rice area in Cambodia is used for lowland rice production (combining wet and dry seasons), so IR varieties would account for 13% of all rice area, or roughly 260,000 hectares. At an average yield of 2.4 t/ha, this means that IR varieties produce 624,000 tons of rice nationally; or about 19% of the total national annual tons of rice produced. National rice production has also been assisted by the release of traditional varieties, that have undergone selection for yield improvement by the CIAP Varietal Improvement Program. However, farmers do not distinguish between the improved strains and the original strains when describing their rice varieties, so it is not possible to estimate the contribution of the improved varieties from this survey data. This underscores the need to give improved varieties new names.

Early maturing IR varieties are apparently spreading in use. ~~In 1993 Dr. Ram Chaudhary of IRRI estimated that 20,000 hectares of Cambodian land were planted with IR varieties. The current estimate represents a 13-fold increase in IR planted area in just 4 years.~~ The spread of IR varieties in Cambodia will be limited by the environment, i.e., most rainfed ecosystems are not suitable for modern varieties. This is why CIAP varietal yield trials include many non-IR varieties.

IR66 is the most popular IR variety, accounting for 11% of the rice area included in the survey (Table 12). As noted earlier, 82% of DS farmers grew IR varieties on 92% of the national DS rice area of this survey. In the dry season, 54% of the farmers surveyed grew IR66, accounting for 60% of the DS land covered by the survey. Pesticide use was associated with growing IR varieties ($\chi^2 = 57.4$, $p < 0.001$). While 55% of IR growers used pesticides, only 31% of other rice farmers used pesticides.

Table 12. Most common lowland rice varieties in Cambodia[1].

Rice Variety	Percentage of national rice growing area	Average yield (t/ha)
Neang Minh	22.6%	0.8
IR66	10.8%	2.3
Phka Khney	6.2%	1.3
Bonla Phdau	6.1%	0.7
Smeu	5.9%	0.8
All other varieties[1]	48.4%	1.7

[1] Farmers named 43 additional varieties, each accounting for less than 4% of the rice growing area

Knowledge of pests and natural enemies

Nationwide, farmers named over 53 different DS pests and 62 different WS pests that they saw in their rice fields. Except for umbrella sedge (*Cyperus difformis*), no particular pest was cited by more than half the respondents. The pests reported by the highest numbers of farmers were umbrella sedge, rats, yellow leaf, stem borers, and jungle rice (*Echinochloa colona*). Yellow leaves can be caused by any number of diseases or nutrient deficiencies. Tungro disease can cause yellow leaves, however, green leafhoppers which vector tungro were rarely reported as pests. Crabs were considered a major pest by 22% of WS growers, but were reported by only 8% of DS growers (Table 13). Caseworm problems were reported by 30% of DS growers and 16% of WS growers. Caseworms should be easier to manage in the dry season when farmers have more control over the water in their fields. Draining rice fields provides good control of caseworms in Cambodia, with damage occurring only in those parts of the field with stagnating water (Kun 1994). However, DS farmers predominantly use pesticides to control caseworms. Only one DS farmer reported controlling caseworms by draining water from the field. Stem borers were perceived as the major DS insect pest in 3 provinces and the major WS insect pest in 5 provinces (Tables 14 and 15).

Farmers are generally aware of damage to their rice, but do not necessarily understand the cause. For example, in Kandal 58% of farmers reported whitehead, though only 26% knew they had stem borers in their fields. Some farmers reported certain types of natural enemies as pests. The most extreme case of this was in Kandal where 43% of DS farmers reported ladybird beetles as pests. Besides eating insects, ladybird beetles do in fact eat rice pollen, but there is no evidence that this has any effect on yield. Except for ladybird beetles, less than 7% of farmers reported any given species of natural enemy as a major pest in any province in any season. Only 1% of farmers mistakenly thought some pests, namely crabs and mole crickets, do not damage rice.

Table 13. Most commonly reported pests of lowland rice.

Pest	%WS Farmers Reporting	%WS Farmers Controlling	% DS Farmers Reporting	% DS Farmers Controlling
INSECTS				
stem borers	25	14	26	20
caseworms	16	6	30	21
crickets	14	1	11	2
leaffolders	15	5	22	12
DISEASES				
yellow leaf	27	9	21	15
brown spot	27	5	18	8
sheath rot	17	2	13	2
WEEDS				
Cyperus difformis	54	51	61	52
Echinochloa colona	27	27	32	29
Paspalum distichum	17	16	9	7
Cyperus iria	8	8	19	17
OTHERS				
rats	30	10	41	26
birds	2	0.1	7	0
crabs	22	10	8	4

Table 14. Most commonly reported DS rice pests in each province and the percentage of farmers reporting it.

Province	Weed	Insect	Mammal	Crustacean	Disease
K. Chhnang	*C. difformis* 74%	stem borer 58%	rat 55%	crab 3%	brown spot 29%
K. Speu	*C. difformis* 76%	stem borer 26%	rat 29%	crab 7%	yellow leaf 21%
Kandal	rice flat sedge 57%	stem borer 100%	rat <1%	crab 0%	blast 61%
Prey Veng	*C. difformis* 80%	rice bug 61%	rat 17%	crab 7%	yellow leaf 66%
Siem Reap	*C. difformis* 58%	grasshopper 16%	rat 79%	crab 3%	sheath rot 18%
Svay Rieng	*C. difformis* 61%	rice bug 64%	rat <1%	crab 0%	brown spot 47%
Takeo	*C. difformis* 48%	caseworm 38%	rat 33%	crab 21%	sheath rot 12%

Table 15. Most commonly reported WS rice pests in each province and the percentage of farmers reporting it.

Province	Weed	Insect	Mammal	Crustacean	Disease
Battambang	Lythraceae 25%	grasshopper 16%	rat 42%	crab 42%	yellow leaf 9%
K. Cham	*C. difformis* 95%	stem borer 70%	rat 32%	crab 43%	yellow leaf 48%
K. Chhnang.	*C. difformis* 60%	stem borer 46%	rat 15%	crab 19%	brown spot 37%
K. Speu	*C. difformis* 74%	stem borer 24%	rat 23%	crab 22%	yellow leaf 55%
Kandal	*C. difformis* 52%	stem borer 20%	rat 47%	crab 38%	sheath rot 30%
Prey Veng.	*C. difformis* 55%	rice bug 32%	rat 5%	crab 2%	yellow leaf 54%
Pursat	*C. difformis 43%*	stem borer 100%	rat 40%	crab 22%	brown spot 12%
Siem Reap	grasses 61%	grasshopper 34%	rat 40%	crab 22%	sheath rot 17%
Svay Rieng	*C. difformis* 62%	rice bug 46%	rat 17%	crab 29%	brown spot 50%
Takeo	*C. difformis* 53%	cricket 25%	rat 19%	crab 13%	sheath rot 28%

Most farmers, 87%, knew that some animals in the field do not damage rice. When asked to give examples of such animals, 75% of all farmers named frogs, 62% said fish, and 32% said spiders. On the average, farmers could only name 3 kinds of animals in the field that do not damage rice. Field observations indicate that the most common wet season predators are veliid bugs (Jahn *et al.* 1996), but farmers did not recognize these insects as natural enemies. Of those farmers aware that some field animals do not damage rice, 66% knew that frogs and other predators eat insects. Over half of the farmers that knew predators eat insects, also knew pesticides could kill natural enemies. About 43% of farmers were unaware that natural enemies exist.

Attitudes toward pesticide use

Farmers were asked to evaluate the correctness of the statement: "Applying pesticides to rice increases yields." The majority of farmers, 59%, agreed with the statement, while 36% disagreed, 4% expressed ignorance, and the remainder said it depends on the situation.

Among the 57% of farmers aware of natural enemies, 33% agreed that killing natural enemies with pesticides can cause pest outbreaks, 45% disagreed, and 22% said they did not know. Overall, only 19% of all the farmers interviewed thought that pesticide applications could produce pest outbreaks by killing natural enemies.

Pest management practices

Over half the WS and DS farmers in each province surveyed, except Siem Reap, practiced some form of weed control (Table 16 and 17). In both seasons, Siem Reap had the smallest percentage of farmers controlling insects, diseases, and weeds. Overall, 82% of all the WS farmers and 75% of all DS farmers practiced some form of weed control. Siem Reap had the highest percentage of WS farmers

practicing rat control. WS crab control was practiced by the highest percentage of farmers in Kandal. Generally, farmers did not attempt bird control.

A greater percentage of farmers reported controlling insects and rats with pesticides than by any other single method. Table 18 indicates the practices which farmers *reported* using to control pests. Sometimes farmers inadvertently controlled pests in the process of following other practices. For example, some farmers placed native apple snails (*Pila* sp.) in their rice fields to raise as food. The snails ate algae; making this farmer practice an effective form of biological control. But no farmers reported controlling algae by this means. Farmers often clipped the tips off of seedlings before planting, to encourage seedling growth and to prevent seedlings from falling over. The practice also removes the eggs of stem borers and other pests, though farmers did not mention this practice when discussing pest management. Other farmer practices which served to control pests, but were not reported as such, included: draining or flooding the field, and planting pest-resistant rice varieties.

Table16. Percentage of wet season farmers that control majors pest groups.

Province	% insect control	% disease control	% weed control	% rat control	% crab control	% bird control
Battambang	6	1	61	12	24	0
Kampong Cham	19	23	99	10	19	0
Kampong Chhnang	19	18	94	2	10	0
Kampong Speu	12	19	95	5	4	0
Kandal	8	7	82	18	28	<1
Prey Veng	17	21	84	0	0	0
Pursat	100	1	88	7	9	0
Siem Reap	2	0	38	33	3	0
Svay Rieng	62	34	87	6	6	0
Takeo	27	4	83	10	3	0
All wet sn. farmers	31	15	82	10	10	<1

Table 17. Percentage of dry season farmers that control majors pest groups.

Province[1]	% insect control	% disease control	% weed control	% rat control	% crab control	% bird control
Kampong Chhnang	68	36	100	29	0	0
Kampong Speu	39	12	95	7	2	0
Kandal	100	57	61	35	0	0
Prey Veng	71	59	96	10	5	< 1
Siem Reap	1	0	31	49	1	0
Svay Rieng	92	39	86	0	0	0
Takeo	48	6	83	23	10	0
All dry sn. farmers	51	25	75	25	4	0

[1] Insufficient data for Kampong Cham

Table 18. How Farmers Manage Pests: the percentage of farmers practicing different pest management techniques.

Pest control technique	*Wet Season*	*Dry Season*
INSECTS		
• commercial pesticide	15	34
• botanical	<1	<1
• ash, salt, or fertilizer	5	12
• smoke	<1	<1
• collecting	13	10
• water management	<1	<1
• varietal resistance	<1	<1
DISEASES		
• commercial pesticide	1	1
• physical	<1	4
• cultural	15	25
WEEDS		
• commercial pesticide	1	1
• manual	82	74
RATS		
• commercial pesticide	9	25
• traps	1	<1
• fences	<1	<1
CRABS		
• commercial pesticide	4	2
• botanical	< 1	0
• traps and manual	7	2

Pesticide use

Pesticide users and non-users did not differ significantly in average age, education, or years of experience farming[2]. The percentage of farmers using pesticides varied greatly from one province to another. Depending on the province, from 8% to 65% of WS farmers, and 40% to 94% of DS farmers, applied pesticides (Tables 19 and 20). In every province a greater percentage of farmers applied pesticides in the DS than in the WS. In both seasons, insecticide use was highest in Svay Rieng. WS herbicide use was highest in Battambang, which is consistent with findings by Rickman *et al.* (1995). None of the farmers used fungicides, though some erroneously applied insecticides for fungal diseases (e.g., brown spot). About 35% of all the farmers interviewed used pesticides. Nationally, 27% of farmers used pesticides in the WS, and 59% in the DS. In both seasons the most popular pesticides were insecticides followed by rodenticides.

Note that Table 18 indicates that 15% of all WS farmers and 34% of all DS farmers interviewed used insecticides for insect control, while Tables 19 and 20 indicate that 20% of all WS farmers and 41% of all DS farmers used insecticides for any reason. In other words, some farmers use insecticides for control of pests other than insects (e.g., crabs, diseases, and rats).

[2] Means compared by two-tailed t-tests

Table 19. Pesticide use in Cambodian lowland rice in the wet season.

PROVINCE	% using pesticide	% using insecticide	% using rodenticide	% using herbicides
Battambang	36	22	12	10
Kampong Cham	16	11	7	2
Kampong Chhnang	8	6	2	2
Kampong Speu	12	9	3	0
Kandal	21	7	17	1
Prey Veng	12	12	0	0
Pursat	14	10	3	1
Siem Reap	33	2	33	0
Svay Rieng	65	65	1	0
Takeo	13	7	8	0
Overall percent	**27**	**20**	**8**	**1**

Table 20. Pesticide use in Cambodian lowland rice in the dry season.

PROVINCE[1]	% using pesticide	% using insecticide	% using rodenticide	% using herbicides
Kampong Chhnang	48	19	29	0
Kampong Speu	40	38	7	0
Kandal	65	48	35	0
Prey Veng	71	66	10	0
Siem Reap	49	1	49	0
Svay Rieng	94	94	0	0
Takeo	54	44	23	0
Overall percent	**59**	**41**	**25**	**1**

[1] Insufficient data for Kampong Cham.

Methyl-parathion, was the most commonly used (known) insecticide nationally (Tables 21). Yech (1994) also found methyl-parathion to be the most common insecticide. Interestingly, methyl-parathion is one of the few pesticides in Cambodian markets found to contain as much active ingredient as indicated on the label (Nesbitt *et al.* 1996). Zinc phosphide was the only rodenticide reported. In every province, either zinc phosphide or methyl-parathion was the most commonly used pesticide. Methyl-parathion use was highest in Svay Rieng, while zinc phosphide use was highest in Siem Reap (Table 22). None of the herbicide users knew what kind of herbicide they use. The herbicides 2,4-D, paraquat, and alachlor are available in Cambodian markets. Pesticides were the most common method of control for the major DS pests, except for weeds.

Among the farmers using pesticides, 93% observed pests or damage to decide when to apply pesticides. The remaining farmers sprayed on a schedule or simply copied their neighbors. Of those who looked for pests or damage, 73% applied pesticides whenever they saw pest damage, 26% sprayed when they observed a certain number of insects (regardless of the type), the remaining 1% of pesticide users consisted of farmers who sprayed whenever they saw any insect, or sprayed certain kinds of insects, or sprayed when pests exceeded predators.

Table 21. All pesticides reported by farmers in survey and percentage of farmers using them in the wet and dry seasons.

Pesticide	Synonyms	Type[1]	Hazard Class	% wet season	% dry season
Zinc Phosphide	Phosvin, Zinc-tox	R	I	8	25
Unknown Insecticides		I		11	18
Methyl-parathion	Folidol, Metaphos	I	I	7	19
Monocrotophos	Azodrin	I	I	2	4
DDT	Zeidane	I	II	1	2
DDVP	Dichlorvos	I	I	<1	1
Diazinon	Basudin, DZN	I	II	<1	1
Malathion	Carbophos	I	III	<1	<1
Sumithion	Fenitrothion	I	III	0	<1
Unknown Herbicides		H		2	1

[1] R = Rodenticide, I = Insecticide, H = Herbicide

Table 22. The percentage of farmers using methyl-parathion and zinc phosphide in each province.

Province	Methyl-parathion		Zinc phosphide	
	%WS users	%DS users	% WS users	% DS users
Battambang	13	No data	12	No data
Kampong Cham	7	Insufficient data	7	Insufficient data
Kampong Chhnang	3	6	2	29
Kampong Speu	1	0	3	7
Kandal	3	35	17	35
Prey Veng	3	22	0	10
Pursat	10	No data	3	No data
Siem Reap	1	0	33	49
Svay Rieng	15	42	1	0
Takeo	6	33	8	23
Overall percent[1]	**7**	**19**	**8**	**25**

[1] The percentage of all farmers surveyed, not an average of the provincial percentages.

Door-to-door sales of pesticides are quite rare in Cambodia. Approximately 99% of all pesticide users purchased pesticides in the local market. Only 5% of pesticide users hired someone to apply pesticides. Those who hired a pesticide applicator paid an average of 4850 riel per farm for this service.

Pesticide users spent an average of 11,858 riel/ha (U.S. $4.74/ha at the 1996 exchange rate) in the WS and 19,951 riel/ha (U.S. $7.98/ha at the 1996 exchange rate of 2500 Riel to the U.S. dollar) in the DS on pesticides (Table 23). WS pesticide users in Kampong Chhnang spent the most per hectare on pesticides. Perhaps pesticide prices in Kampong Chhnang are higher than those provinces bordering Thailand or Vietnam, the source of most pesticides in Cambodia.

Table 23. Average pesticide expenditure in riel per hectare in each province, excluding non-users of pesticides.[1]

Province	WS Riel/ha	DS Riel/ha
Battambang	7310	No data
Kampong Cham	8621	Insufficient data
Kampong Chhnang	48942	18640
Kampong Speu	25734	35115
Kandal	22343	21039
Prey Veng	13185	27595
Pursat	6227	No data
Siem Reap	5900	6806
Svay Rieng	9321	25343
Takeo	20721	9037
Average[2]	**11858**	**19951**

[1] 1996 exchange rate: U.S. $1.00 = 2500 Riel.
[2] The average of all farmers surveyed, not an average of the provincial means.

For the 10 provinces surveyed, the overall average pesticide expenditure was 3073 Riel/ha (U.S. $1.22) in the WS and 11,682 Riel/ha (U.S. $4.67) in the DS. This figure includes all farmers surveyed, not just pesticide users. Svay Rieng had the highest average pesticide expenditure per hectare (Table 24). This is not surprising since Svay Rieng had the highest percentage of pesticide users (Tables 19 and 20).

Table 24. Overall average pesticide expenditure in riel per hectare in each province, including non-users of pesticides.[1]

Province	WS Riel/ha	DS Riel/ha
Battambang	2703	No data
Kampong Cham	1379	Insufficient data
Kampong Chhnang	3915	9019
Kampong Speu	2722	14213
Kandal	4551	13721
Prey Veng	1572	19519
Pursat	866	No data
Siem Reap	1967	3355
Svay Rieng	5488	22527
Takeo	2711	4866
Average[2]	**3073**	**11682**

[1] 1996 exchange rate: U.S. $1.00 = 2500 Riel.
[2] The average of all farmers surveyed, not an average of the provincial means.

Insecticide applications at the tillering stage were the most common form of insecticide use. Roughly a quarter of dry season farmers and 9% of wet season farmers applied insecticides at the tillering stage (Tables 25 and 26).

Table 25. Wet Season pesticide use in Cambodian lowland rice at each stage. 1223 farmers surveyed.

Crop Stage[1]	Type of pesticide[2]	% wet season farmers applying pesticide	Average amount applied (excluding non-users)	Standard Deviation
Seedling	Insecticide	4.1	0.6 l/ha	0.60
	Rodenticide	0.0	0.0	0.00
	Herbicide	0.5	0.9 l/ha	0.32
Tillering	Insecticide	8.7	0.5 l/ha	0.68
	Rodenticide	2.7	0.5 kg/ha	0.65
	Herbicide	1.3	0.3 l/ha	0.33
Booting	Insecticide	1.9	0.7 l/ha	0.60
	Rodenticide	5.6	0.3 kg/ha	0.27
	Herbicide	0.0	0.0	0.00
Heading & Flowering	Insecticide	0.6	1.2 l/ha	0.49
	Rodenticide	1.0	0.4 kg/ha	0.22
	Herbicide	0.0	0.0	0.00
Milk	Insecticide	0.7	0.6 l/ha	0.30
	Rodenticide	0.4	0.3 kg/ha	0.17
	Herbicide	0.0	0.0	0.00

1 No farmers applied pesticide beyond the milk stage.
2 No farmers used fungicide.

Table 26. Dry Season pesticide use in Cambodian lowland rice at each stage. 304 farmers surveyed.

Crop Stage[1]	Type of pesticide[2]	% dry season farmers applying the pesticide	Average amount applied (excluding non-users)	Standard Deviation
Seedling	Insecticide	5.3	0.7 l/ha	0.83
	Rodenticide	0.0	0.0	0.00
	Herbicide	0.0	0.0	0.00
Tillering	Insecticide	25.7	0.6 l/ha	0.70
	Rodenticide	10.2	0.3 kg/ha	0.35
	Herbicide	0.7	1.0 l/ha	1.39
Booting	Insecticide	12.8	0.7 l/ha	0.87
	Rodenticide	15.5	0.4 kg/ha	0.64
	Herbicide	0.0	0.0	0.00
Heading & Flowering	Insecticide	6.9	0.6 l/ha	0.59
	Rodenticide	3.3	0.6 kg/ha	0.46
	Herbicide	0.0	0.0	0.00
Milk	Insecticide	6.9	0.6 l/ha	0.56
	Rodenticide	1.0	0.4 kg/ha	0.21
	Herbicide	0.0	0.0	0.00

1 < 0.1% of farmers applied a pesticide beyond the milk stage.
2 No farmers used fungicide.

The 10 provinces in this survey have 1.3 million hectares of WS lowland rice and 159,000 hectares of DS lowland rice (Javier 1996). Assuming that insecticides were used by 20% of WS farmers and 41% of DS farmers (Tables 19 and 20) and that the same percentage of rice received insecticides, then, approximately 260,000 ha of WS rice and 65,000 ha of DS rice received insecticide applications. Farmers

were generally uncertain how many times they applied pesticides in a season, but knew at which stages of the rice they applied pesticides. By counting the number of stages they applied pesticides, we were able to determine the minimum number of pesticide applications in a season for each farmer. In the DS, farmers applied an average of 0.7 liters/ha of insecticide, at least an average of 2.7 times. We estimate, therefore, that DS farmers (in these 10 provinces) applied at least 123,000 liters of insecticide. WS farmers applied an average of 0.5 liters/ha of insecticide at least 1.3 times, for a total of 169,000 liters of insecticide. Thus, we estimate that at least 292,000 liters of insecticides were applied annually to the lowland rice in the 10 provinces covered by this survey.

Among pesticide users, 58% of WS and 53% of DS farmers used knapsack sprayers. Only 3% of pesticide users poured insecticides into bowls and flicked the chemicals over their fields with brushes or leaves. About 9% of pesticide users employed a home made plunger-type sprayer that squirts large volumes of pesticide over a few spots in the field. These plunger-sprayers consist of one metal or bamboo tube inside of another. They are generally used for applying insecticides to the seedbed. The remainder of farmers mix pesticides with bait and place it in the field. Only 3% of farmers using pesticides, regularly mixed different kinds of pesticides together. Likewise, 3% of pesticide users mixed fertilizer with pesticides. About 75% of farmers diluted pesticides with water, but only 1% added an emulsifier (e.g., soap). The majority of pesticide users, 58%, mixed pesticides in a knapsack sprayer; 14% mixed pesticides in a bucket, and 28% in a bait container. A small number of pesticide users, 2%, mixed pesticides in the same container that they used to fetch drinking water or feed domestic animals.

Cultural and physical control

Farmers controlled weeds mainly through hand weeding. Diseased or pest-damaged rice plants were commonly pulled from the fields.

Botanical pest control

A few farmers mentioned that they chop up a cactuslike plant, the dragon bone plant (*Euphorbia lactea*), and place it in the water to kill or repel crabs. A few farmers reported that when they see yellow rice plants in the field, they stick *Chromolaena odorata* branches into the ground upright to make a fence around the yellow rice, which then turns green within a week. *C. odorata,* called *kanthraing khait* in Khmer, is usually not cultivated, but grows wild. Joshi *et al.* (1994) reported that some farmers chopped up the leaves of *C. odorata,* eucalyptus, or papaya and broadcast them in the paddy to drive away crabs or insects. Eucalyptus oils are known to repel ants (Jahn 1991), but we are not aware of any studies on the insect repellent effects of papaya or *C. odorata.* Channer (1997) reported that one Cambodian rice farmer used leaves of the neem tree (*Azadirachta indica*) for crab control in the field. Some farmers use neem leaves to help preserve stored grain. The neem tree is common in Cambodia and neem parts are used in the traditional Khmer diet and medicine. Neem leaves and extracts are well documented to have adverse effects on many insects (Lim and Bottrell 1994). However, crude neem extracts do not necessarily raise rice yields when used in the same manner as synthetic insecticides (Jahn 1992).

Unusual pest management practices

A number of farmers treat pest problems by applying handfuls of fertilizer, ashes, or salt to the damaged area. A small number use smoke to drive away rice bugs and other insects. A few farmers unwound old video tapes, and encircled their

fields with them to scare off birds. Supposedly the fluttering tapes reflecting light keeps birds away. Rapusas *et al.* (1989) reported that some farmers mix fish oil with crushed rice bugs to attract rice bugs to traps. In complete contradiction, other farmers report crushing rice bugs and using the extract as a rice bug repellent.

Information transfer

About 21% of farmers received no advice on pest management. Only 11% of all farmers were aware of any training ever conducted in their area. Only 5% of all farmers ever attended a training course. However, 97% of these people thought the training was worthwhile. About 41% of trained farmers studied integrated pest management (IPM), about 25% studied safe pesticide use, and the remainder took training courses on agricultural subjects unrelated to pest management.

Over half of the farmers received pest management advice from neighbors while only 15% received advice from extension agents. The highest use of extension agents for advice was in Siem Reap, where none of the farmers reported getting advice from pesticide sellers (Table 27). Interestingly, Siem Reap had the lowest percentage of farmers using insecticide (Tables 19 and 20). The highest percentage of farmers who get advice from pesticide sellers was in Svay Rieng (Table 27), where insecticide use was highest (Tables 19 and 20). One farmer told us that he does not get advice but performs his own experiments to see what works best.

Table 27. Percentage of farm households receiving pest management advice from various sources in each province.[1]

Province	Neighbors & Relatives	Radio	Extension	TV	Pesticide sellers
Battambang	79	5	3	0	3
K. Cham	35	35	20	14	5
K. Chhnang	41	42	16	5	4
K. Speu	54	39	31	16	5
Kandal	43	16	6	2	4
Prey Veng	53	41	13	14	10
Pursat	30	4	4	1	2
Siem Reap	30	3	38	0	0
Svay Rieng	67	19	15	3	16
Takeo	64	23	13	13	2
Overall percent[2]	**52**	**22**	**15**	**6**	**6**

[1] Some respondents received no advice or received advice from multiple sources.
[2] The percentage of all the farmers surveyed; not an average of the provincial percentages.

Those naming more than one source of pest management advice were asked which source they considered the most credible. In every province except Siem Reap, the greatest percentage of farmers thought that neighbors were the most credible source. In Siem Reap extension agents were named as the most credible source by 54% of respondents. Nationally, 50% of farmers thought neighbors the most credible source, followed by extension and radio. That only 6% of farmers thought TV the most credible while 19% thought radio the most credible is probably because fewer farmers have access to TV. People who sell pesticides were not considered credible sources by many farmers. Even in Svay Rieng, where 16% of farmers receive advice from sales people, only 6% of farmers thought sellers were the most credible source (Tables 27 and 28).

Table 28. Percentage of various responses to the question "Which source of information on pest management do you consider most credible?"[1]

Province	Neighbors & Relatives	Radio	Extension	TV	Pesticide sellers	None
K. Cham	26	21	17	3	2	31
K. Chhnang	41	35	17	3	4	0
K. Speu	46	15	28	8	1	0
Kandal	70	19	9	0	2	0
Prey Veng	46	32	13	4	4	0
Siem Reap	44	3	54	0	0	0
Svay Rieng	64	9	17	1	6	3
Takeo	49	24	15	10	2	0
Overall percent[2]	**50**	**19**	**20**	**4**	**3**	**4**

[1] Farmers in Battambang and Pursat only named one source of information, or declined to say which source was most credible.
[2] The percentage of the all farmers surveyed, not an average of the provincial percentages.

We asked farmers what subjects they would like to know more about. Farmers were free to name any subject, i.e., they were not given a set of pre-determined choices. We grouped the subjects named by the farmers into the categories: pests, pesticides, fertilizers, and farm management. Overall, pests were the most common subject of inquiry (Tables 29). In five provinces a greater percentage of farmers were interested in fertilizer than pests.

When asked how they would like to get information, most farmers preferred schools or training courses. Only in Svay Rieng did any farmers express an interest in receiving information via extension services (Table 30).

Table 29. Percentage of farmers in each province requesting more information on various subjects in response to the question "What would you like to learn more about?".[1]

Province	Pests	Fertilizer	Pesticides	Farm Management	Nothing
Battambang	7	33	8	5	46
K. Cham	17	45	32	50	0
K. Chhnang	40	25	22	9	22
K. Speu	38	24	19	17	14
Kandal	23	34	21	24	18
Prey Veng	60	18	20	14	4
Pursat	19	49	5	3	28
Siem Reap	38	18	11	22	28
Svay Rieng	56	3	20	3	2
Takeo	38	44	12	28	23
Overall percent[2]	**36**	**26**	**17**	**16**	**17**

[1] Some respondents named more than one subject, or preferred not to respond so totals do not necessarily equal 100% for each province.
[2] The percentage of all farmers surveyed, not an average of the provincial percentages.

Table 30. Percentage of farmers preferring to receive information by various means.

Province	School or Training	Written Material	Radio	Extension	TV
Battambang	34	10	40	0	13
K. Cham	46	45	4	0	5
K. Chhnang	36	20	30	0	5
K. Speu	40	8	38	0	12
Kandal	54	29	20	0	15
Prey Veng	75	13	8	0	2
Pursat	33	15	36	0	0
Siem Reap	46	27	21	0	6
Svay Rieng	47	36	7	6	0
Takeo	46	20	24	0	10
Overall percent	**46**	**23**	**21**	**1**	**6**

Pest control and the relationship to yield and other factors

Yield and pest control

Farmers were asked how much rice they harvested from their largest fields in the last season. These data were converted to t/ha and entered into the Excel® database for statistical analysis. National average DS yields of 2.5 t/ha were significantly higher than average WS yields of 1.3 t/ha ($P < 0.05$). Farmers controlling pests, regardless of method, had higher average yields than farmers that did not control pests in both seasons. Also, farmers using fertilizer had significantly higher yields than those not using fertilizer in both seasons (Table 31). Since pest control was associated with fertilizer use in both seasons (Table 32), we compared the yields of those farmers controlling and not controlling pests among fertilizer users, and among nonusers of fertilizer in both seasons. This analysis indicated that pest control produced significantly higher yields, except among the 8 DS fertilizer users who claimed not to practice pest control (Table 33). However, all 8 of those farmers grew pest-resistant rice varieties.

The category "pest control" includes all methods of pest management (e.g. manual weeding, traps, pesticides). To see if pesticides themselves have a measurable effect on average yield, we compared the yields of pesticide users to the yields of farmer not practicing any pest control. Pesticide users did not have significantly higher yields in either season. In fact, in the wet season, farmers using pesticides had significantly lower yields (Table 34). This may indicate that WS farmers do more harm than good with their pesticide applications (e.g., by destroying natural enemies). Alternatively, it may mean that the pesticides are being applied in the WS after the pests have already reduced yields.

Table 31. Lowland yield differences in relation to pest control and fertilizer use.[1]

	DRY SEASON				WET SEASON			
	n	Mean yield (t/ha)	P	SD	n	Mean yield (t/ha)	P	SD
Pest control	270	2.4	< 0.001	1.63	1075	1.4	< 0.001	1.08
No pest control	34	1.4		1.32	148	0.9		0.90
Fertilizer	214	2.7	< 0.001	1.64	1009	1.4	< 0.001	1.09
No fertilizer	90	1.4		1.20	214	1.0		0.90

[1]Significance (P) and standard deviation (SD) determined by two-tailed Student's T-test.

Table 32. Contingency tables showing the relationship between pest control and fertilizer use in Cambodian lowland rice.

DRY SEASON: $\chi^2 = 38.41$, $p < 0.001$

	PEST CONTROL	NO CONTROL	Totals
FERTILIZER	206	8	214
NO FERTILIZER	64	25	89
Totals	270	33	303

WET SEASON: $\chi^2 = 69.41$, $p < 0.001$

	PEST CONTROL	NO CONTROL	Totals
FERTILIZER	923	86	1009
NO FERTILIZER	152	62	214
Totals	1075	148	1223

Table 33. Yield differences in relation to pest control among users and non-users of fertilizer[1].

	DRY SEASON				WET SEASON			
	n	Mean yield (t/ha)	P	SD	n	Mean yield (t/ha)	P	SD
FERTILIZER								
Pest control	206	2.9	0.81	1.50	923	1.4	< 0.001	1.10
No pest control	8	3.0		1.37	86	1.0		0.94
NO FERTILIZER								
Pest control	64	1.7	< 0.01	1.24	152	1.1	< 0.01	0.91
No pest control	25	1.0		0.84	62	0.7		0.81

[1]Significance (P) and standard deviation (SD) determined by two-tailed Student's T-test.

Table 34. Lowland yield differences in relation to pesticide[1] .

	DRY SEASON				WET SEASON			
	n	Mean yield (t/ha)	P	SD	n	Mean yield (t/ha)	P	SD
Pesticide	181	2.5	0.43	1.49	351	1.1	< 0.001	1.07
No pest control	122	2.4		1.63	866	1.4		1.05

[1]Significance (P) and standard deviation (SD) determined by two-tailed Student's T-test.

Sociodemographic factors and pesticide use

Males were more likely than females to use pesticides (Table 35). Overall, 36% of men and 29% of women reported using pesticides. Even when female farmers used pesticides they generally had a male, usually a relative, apply the chemicals. Among those households where pesticides were used on rice, 95% reported that a male usually applied the pesticides; in 4% of the households females applied pesticides; and only 1% of the households reported that both men and women applied pesticides. Our survey detected no significant differences (using two tailed t-test) in the national average age, education, or experience of pesticide users and nonusers.

Table 35. Contingency table showing the association between pesticide use and gender.

$\chi^2 = 6.997$ $p < 0.001$

	Pesticides Used	Pesticides Not Used	Totals
Males	259	463	726
Females	154	381	537
Totals	413	466	885

CONCLUSIONS

Farmer knowledge

Farmers were usually aware of pest damage, but did not necessarily understand the cause. For example, more farmers reported deadheart and whitehead, than reported stem borer. In general, farmers had a poor understanding of the broad spectrum nature of pesticides, as indicated by the fact that only 19% of respondents believed pesticides could cause pest outbreaks. An awareness of natural enemies was common, but their importance in the rice ecosystem was often not grasped. In some villages, certain types of natural enemies, e.g., ladybird beetles, were mistaken for pests.

Farmer practices

In both seasons the majority of lowland farmers transplanted their rice. In the WS, most farmers planted traditional, late maturing varieties; while in the DS most farmers planted the modern, early maturing varieties. Pesticide use was higher in the DS than in the WS, and pesticide use was positively associated with growing IR varieties. About 27% of WS farmers used pesticides, compared to 59% of DS farmers. Overall, 35% of the farmers interviewed used pesticides. Most pesticide users, 93%, decided to spray when they saw pests or damage, while spraying on a schedule was rare. Approximately 58% of WS pesticide users and 53% of DS pesticide users applied pesticide with a knapsack sprayer. Fertilizer applications and pest control, each significantly increased yields in both seasons, but pesticides did not significantly increase yields.

Sociodemographic factors

Most lowland rice farmers, 52%, receive pest management advice from neighbors or relatives, while only 15% receive advice from extension agents. While roughly a third of the farmers surveyed used pesticides, only 6% claimed to receive pest management advice from pesticide sellers. In both seasons a greater percentage of men than women used pesticides. Among households using pesticides, 95% reported that a male usually applies the pesticide. Pesticide users and nonusers did not differ significantly in national average age, education, or years of farming experience.

Implications of results for research

Rice pest constraints

Farmers named over 50 different pests that cause problems in their rice fields. With the exception of umbrella sedge, no single pest species or disease was cited as a problem by more than half the farmers in either season. To determine which of the pests named by farmers actually constrain yields, the CIAP IPM Program is conducting a rice pest constraint (RPC) study. Tungrolike symptoms were reported in both the WS and DS. To determine if tungro is present in Cambodia, Dr. Azzam Ossmat a plant pathologist from IRRI searched the country with the CIAP IPM team to collect yellow rice leaves and test them for the presence of viruses. Out of 720 leaf samples collected from 26 fields, only two samples tested positive for rice tungro bacilliform and spherical virus.

Effects of pest management practices on yields

The CIAP IPM Program is conducting non-parametric analysis of the RPC yield data to see if the relationship between fertilizers, pesticides, and yield is the same as indicated in this survey. In addition, we have conducted replicated field trials comparing the yields of untreated plots and plots treated with pesticides by farmers following their usual practices.

Effects of cropping practices on pest dynamics, biodiversity and yields

Pesticide use was associated with growing IR varieties. Although the reported yields of IR varieties were significantly higher than other varieties, the reported yields of pesticide users were not significantly higher than those of farmers who did not practice pest control. This raises the question of whether or not the association between IR varieties and pesticides is actually justified by pest problems. To evaluate if the diversity of pests and pest dynamics in traditional and modern varieties is different, the CIAP IPM Program is comparing modern and traditional varieties in randomized complete block trials. We're also comparing the biodiversity of single to double cropped IR fields. In addition, the CIAP research programs are collaborating to compare the pest dynamics and yields of different combinations of rice varieties and fertilizer rates side-by-side in over 100 farmer's fields over several seasons.

Botanical control

Over a fifth of WS farmers reported that crabs are a pest problem. A few farmers reported that placing pieces of the dragon bone plant (*Euphorbia lactea*) in the water will prevent crab damage. The CIAP IPM Program is conducting experiments to see if this technique has any potential.

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