

Escaping the Lock-in to Pesticide Use: Do Vietnamese Farmers Respond to Flower Strips as a Restoration Practice or Pest Management Action?

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Table S1 Sections and questions from the questionnaire used during structured interviews with farmers in the Mekong Delta Region, Vietnam

Question number	Question/Data Captured ¹	Valid Answers
Preliminary		
i	Respondent code	305
ii	Village	305
Farmer Profiles		
1	Age	305
2	Gender	305
3	Education	305
4	Is rice farming your main occupation?	305
5	Aside from rice farming, what are your other income-generating activities?	305
6	How many years have you been growing rice?	305
7	Do you own your own land? (Explain land ownership)	305
Ecological Engineering Experience		
8	Do you grow plants on your bunds (ecological engineering)?	305
9	What plants do you grow on the rice bunds?	133 ²
Farming Profile [based on largest single area of rice cropped during 2014-2015]		
10	What is the total size of your farm?	305
11	Main rice variety	294
12	Date of sowing/transplanting (month)	294
13	Age of seedlings at sowing/transplanting	287
14	Date (actual or expected) of harvest (month)	294
15	Type and amount of fertilizer applied	289
16	Total yield from rice area (t/ha)	294
17	How long was the fallow between harvest and planting?	283
18	In the last 3 years, did you rotate your rice with other crops? (details)	305
Pest/Weed Management		
19	Pest problems experienced during season (ranked 1-5)	283
20	Varietal resistance for main rice variety	248/192 ³
21	How often was herbicide applied? (details)	294
22	How often was insecticide applied? (details)	294
23	Which insecticide was used each season (insecticide/respective pest/who recommended/number of applications/effectiveness)	256
24	How often was molluscicide applied? (details)	294
25	How often was fungicide applied? (details)	294

1: 'Details' indicated that farmers were further questioned on the timing of practices, inputs used, etc.; 2: 133 farmers were currently practicing ecological engineering; 3: 248 farmers answered a question about whether their main rice variety was resistant or not, but only 192 indicated which pest or disease the variety was resistant to

Table S2 List of predictor variables included in the calculation of the DistLM models

Predicting Variable	Type of Variable and Levels
Age	Numerical
Declared resistance	Categorical, 2 levels: Yes, No
Disease resistance	Categorical, 2 levels: Yes, No
Education	Categorical, 4 levels: Primary, Secondary, Higher, College
Fallow	Numerical
Farm type	Categorical, 2 levels: Conventional, Ecological engineering
Farming experience	Numerical
Nitrogen	Numerical
Other crops	Categorical, 2 levels: Yes, No
Ownership	Categorical, 2 levels: Yes, No
Pest resistance	Categorical, 2 levels: Yes, No
Phosphorus	Numerical
Potassium	Numerical
Rice area	Numerical
Type of planting	Categorical, 3 levels: Hand direct sowing, sowing machine, transplanting
Variety	Categorical, 22 levels: one for each variety
Village	Categorical, 12 levels: one for each village

Table S3 Farmer profiles at 12 villages/village groups

Village 1	Farm type 2	N	Farmers that abandoned EE (%)	Average age (years)3	Female s (%)	Rice farming experience (years)3	Education (%)4			Rice farming as main occupatio n (%)4	Farm other crops4	Years of Ecological engineering 5
							Primary school	Secondar y school	High school or above			
v1	C	9	44.44	55.56 (3.06)c		36.33 (2.32)c	77.78	22.22		100.00	55.56	
	EE	18		53.33 (2.74)		30.67 (2.92)	44.44	44.44	11.11	94.44	61.11	1.67 (0.32)ab
v2	C	11	0.00	56.10 (3.54)c		33.10 (4.82)bc	36.36	27.27	36.36	90.91	44.44	
	EE	4		47.50 (4.21)		23.75 (2.39)	0.00	75.00	25.00	100.00	75.00	0.50 (0.50)a
v3	c	4	0.00	47.00 (2.97)abc		21.00 (7.01)bc	25.00	25.00	50.00	100.00	50.00	
	EE	11		50.18 (2.50)		29.82 (3.46)	18.18	63.64	18.18	100.00	54.55	6.18 (2.93)b
g4	C	31	3.23	50.61 (1.24)abc	6.45	18.61 (1.33)abc	67.74	0.00	32.26	77.42	19.35	
	EE	29		47.52 (2.14)	3.45	26.97 (2.21)	13.79	62.07	24.14	96.55	3.45	4.03 (0.16)ab
v5	C	15	13.33	50.27 (2.23)abc		26.27 (2.00)bc	13.33	53.33	33.33	100.00	0.00	
	EE	7		49.71 (4.85)		27.14 (2.88)	28.57	42.86	28.57	85.71	42.86	4.00 (0.65)ab
v6	C	6	33.33	54.17 (4.28)abc		24.17 (4.90)ab	50.00	50.00	0.00	100.00	0.00	
	EE	6		41.17 (3.28)		17.50 (1.71)	16.67	33.33	50.00	100.00	33.33	6.33 (2.15)b
g7	C	13	53.85	51.08 (3.37)abc		28.85 (3.24)bc	46.15	38.46	15.38	92.31	23.08	
	EE	12		51.83 (4.28)		29.67 (3.64)	16.67	50.00	33.33	100.00	16.67	4.83 (0.42)ab
v8	C	19	26.32	46.21 (1.91)abc	36.84	26.79 (2.23)bc	5.26	63.16	31.58	100.00	38.89	
	EE	11		48.64 (1.87)	9.09	30.00 (2.24)	27.27	54.55	18.18	100.00	45.45	5.36 (1.06)ab
v9	C	19	10.53	52.16 (3.27)abc	10.53	24.74 (2.75)abc	21.05	57.89	21.05	100.00	68.42	
	EE	11		52.00 (4.14)	9.09	17.27 (4.34)	27.27	54.55	18.18	100.00	100.00	5.36 (1.09)ab
v10	C	21	23.81	44.71 (2.77)a	4.76	23.81 (3.33)abc	33.33	42.86	23.81	100.00	57.14	
	EE	9		44.11 (3.12)		23.78 (3.68)	11.11	55.56	33.33	100.00	77.78	2.00 (0.67)ab
v11	C	5	0.00	50.80 (5.56)bc		9.00 (1.67)a	40.00	40.00	20.00	20.00	40.00	
	EE	5		54.40 (2.84)		20.60 (4.88)	60.00	20.00	20.00	0.00	0.00	3.80 (0.73)ab
g12	C	20	40.00	45.25 (2.21)ab	10.00	23.10 (2.43)abc	10.00	55.00	35.00	100.00	50.00	
	EE	10		45.30 (3.32)	10.00	23.60 (3.60)	80.00	20.00	0.00	100.00	20.00	2.70 (0.15)ab

Village	1.858*	3.647***	130.730n s	195.500ns	78.907ns	2.483**
Farm type	0.292ns	0.078ns	10.885ns	15.810ns	10.585ns	
Village x Farm type	0.729ns	1.893*				

1: Identifiers relate to villages/group in Figure 2, 'v' and 'g' denote villages and village groups, respectively. 2: 'C' = conventional, 'EE' = ecological engineering; 3: ns = $P > 0.05$, * = $P \leq 0.05$, *** = $P \leq 0.005$, DF village = 11, farm type = 1, interaction = 11, error = 280, lowercase letters indicate homogenous groups; 4: DF = 20; 5: *** = $P \leq 0.005$, DF village = 11, error = 121, lowercase letters indicate homogenous groups

Table S4: Farmer land ownership and land areas at 12 villages/village groups with percentages of farmers rotating rice with other crops in some years

Village ¹	Farm type ²	N	Farm area (ha) ³	Farming own land (%) ⁴	Ownership (%) ⁵			Rotate crop (%) ⁴
					Owner	Renting	Tenant	
v1	C	9	0.36 (0.04)a	100.00	100.00	0.00	0.00	0.00
	EE	18	0.94 (0.16)	100.00	100.00	5.56	50.00	0.00
v2	C	11	0.52 (0.09)a	100.00	100.00	0.00	0.00	0.00
	EE	4	0.70 (0.20)	75.00	75.00	0.00	0.00	50.00
v3	C	4	0.85 (0.32)a	100.00	100.00	0.00	0.00	0.00
	EE	11	0.88 (0.20)	90.91	90.91	0.00	9.09	9.09
g4	C	31	0.74 (0.06)a	61.29	96.77	3.23	0.00	0.00
	EE	29	1.00 (0.10)	100.00	100.00	0.00	0.00	0.00
v5	C	15	2.91 (0.47)d	100.00	100.00	0.00	0.00	0.00
	EE	7	5.01 (1.12)	100.00	100.00	42.86	0.00	14.29
v6	C	6	2.43 (0.29)cd	100.00	100.00	0.00	0.00	0.00
	EE	6	3.25 (0.76)	100.00	100.00	50.00	14.29	0.00
g7	C	13	2.79 (0.30)d	100.00	100.00	0.00	0.00	0.00
	EE	12	4.68 (0.95)	100.00	100.00	0.00	0.00	0.00
v8	C	19	2.57 (0.33)bcd	94.74	100.00	0.00	0.00	26.32
	EE	11	2.63 (0.41)	100.00	100.00	0.00	0.00	9.09
v9	C	19	1.94 (0.56)abc	100.00	100.00	0.00	61.90	100.00
	EE	11	0.67 (0.20)	100.00	100.00	0.00	100.00	100.00
v10	C	21	1.82 (0.22)abc	100.00	100.00	0.00	100.00	61.90
	EE	9	1.50 (0.17)	100.00	100.00	0.00	100.00	100.00
v11	C	5	1.00 (0.21)ab	100.00	100.00	0.00	100.00	100.00
	EE	5	1.56 (0.21)	100.00	100.00	0.00	100.00	100.00
g12	C	20	1.47 (0.19)abc	100.00	100.00	0.00	26.32	0.00
	EE	10	1.83 (0.19)	100.00	100.00	0.00	9.09	0.00
Village			17.337***	122.843ns				121.855ns
Farm type			5.994*	25.346ns				27.443ns
Village × farm type			2.739***					

1: Identifiers relate to villages/group in Figure 2, 'v' and 'g' denote villages and village groups, respectively. 2: 'C' = conventional, 'EE' = ecological engineering; 3: ns = $P > 0.05$, * = $P \leq 0.05$, *** = $P \leq 0.005$, DF village = 11, farm type = 1, interaction = 11, error = 280, lowercase letters indicate homogenous groups; 4: DF = 20.

Table S5: PERMANOVA pair-wise test results of differences between villages in plant species bund composition

	Villages												Most represented species (%)		
	v2	v1	v3	g4	g7	v5	v6	g12	v10	v11	v9	v8	Cosmos	Butterdaisy	Lantana
v2	x	0.011	0.003	0.001	0.095	0.038	0.0402	0.01	0.014	0.292	0.041	0.060			
v1	0.011	x	0.001	0.001	0.001	0.024	0.001	0.019	0.001	0.001	0.001	0.001	99.41		
v3	0.003	0.001	x	0.001	0.072	0.230	0.002	0.002	0.003	0.002	0.017	0.151			
g4	0.001	0.001	0.001	x	0.001	0.012	0.001	0.001	0.001	0.001	0.001	0.001	39.94	20.33	14.31
g7	0.095	0.001	0.072	0.001	x	0.240	0.069	0.001	0.007	0.006	0.208	0.309			
v5	0.038	0.024	0.230	0.012	0.024	x	0.041	0.024	0.034	0.001	0.727	0.692			
v6	0.402	0.001	0.002	0.001	0.069	0.041	x	0.002	0.007	0.098	0.198	0.223			
g12	0.010	0.019	0.002	0.001	0.001	0.024	0.002	x	0.030	0.001	0.001	0.002	88.15		
v10	0.014	0.001	0.003	0.001	0.007	0.034	0.007	0.030	x	0.001	0.009	0.004	48.73	34.85	
v11	0.292	0.001	0.002	0.001	0.006	0.001	0.098	0.001	0.001	x	0.007	0.008			
v9	0.041	0.001	0.017	0.001	0.208	0.727	0.198	0.001	0.009	0.007	x	0.898			
v8	0.060	0.001	0.151	0.001	0.309	0.692	0.223	0.002	0.004	0.008	0.898	x			

Black font indicates significant P-values ($P < 0.05$). SIMPER results are shown for those villages that were significantly different from all other villages, with the most represented plant species at each distinct village.

Table S6. Flowering plants grown on bunds as indicated in Figure 3

Plant species	Scientific names
Vegetables	
Lady finger	<i>Abelmoschus esculentus</i> (L.) Moench
Mung bean	<i>Vigna radiata</i> (L.) R. Wilczek
Sesame	<i>Sesamum indicum</i> L.
Chili	<i>Capsicum</i> spp.
Squash	<i>Cucurbita</i> spp.
Bitter melon	<i>Momordica</i> spp.
Eggplant	<i>Solanum melongena</i> L.
Cucumber	<i>Cucumis sativus</i> L.
Gourd	<i>Lagenaria</i> spp.
Watermelon	<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai
Blackbean	<i>Phaseolus</i> spp.
Ginger	<i>Zingiber officinale</i> Roscoe
Stringbean	<i>Vigna unguiculata</i> (L.) Walp.
Cinnamon	<i>Cinnamomum verum</i> J.Presi
Flowers	
Cosmos	<i>Cosmos</i> spp.
Butter daisy	<i>Melampodium</i> spp.
Sunflower	<i>Helianthus annuus</i> L.
Marigold	<i>Tagetes</i> spp.
Lantana	<i>Lantana camara</i> L.
Blackjack	<i>Bidens pilosa</i> L.
Wild pea	<i>Macroptilium lathyroides</i> (L.) Urb.
Zizania	<i>Chrysogonum peruvianum</i> L.
Dahlia	<i>Dahlia pinnata</i> Cav.
Jasmine	<i>Jasminum</i> spp.
Other plants	
Weeds	Various species
Mango	<i>Mangifera indica</i> L.
Eucalyptus	<i>Eucalyptus</i> spp.
Cajuput	<i>Melaleuca</i> spp.

Table S7: Varieties planted by rice farmers at 12 villages/village groups with farmers' perceptions of pest and disease resistance for each variety

Village1	Farm type2	Varieties grown (% of farmers x seasons)																			
		OM5451	IR50404	Jasmine 85	OM6976	OM4900	OM4218	C10	OM7347	BTE-1	OM4625	Nep/Nep 46	RVT	AG103	Nang hoa	OM6162	DS1	OM2518	ML48	Unknown	
v1	C					11.11		55.56		33.33											
	EE	14.00			4.00	24.00		24.00	6.00	18.00			8.00	2.00							
v2	C							90.32		9.68											
	EE							100.00													
v3	C		100.00																		
	EE		100.00																		
g4	C	19.35	80.65																		
	EE	97.70	1.15			1.15															
v5	C	4.44		15.56	35.56	6.67	37.78														
	EE	3.85		11.54	53.85	19.23	3.85							3.85			3.85				
v6	C	5.56		33.33			50.00			5.56				5.56							
	EE	5.56	5.56	44.44			38.89			5.56											
g7	C	2.70	59.46	16.22	10.81	0.00	10.81														
	EE		2.86	68.57	11.43	2.86	5.71													8.57	
v8	C	13.46	46.15	40.38																	
	EE	15.15	54.55	30.30																	
v9	C	86.84	2.63		2.63												5.26		2.63		
	EE	54.55	31.82		13.64																
v10	C	24.00	10.00		34.00	16.00				6.00		2.00							8.00		
	EE	33.33				11.11				38.89					16.67						
v11	C											100.00									
	EE											100.00									
g12	C	86.67	1.67			8.33							3.33								
	EE	33.33			10.00	40.00				10.00			6.67								
Farmers growing (% of 305)		37.25	30.39	17.97	12.42	9.15	7.52	4.25	3.15	3.15	2.29	2.29	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Farmers' beliefs regarding varietal resistance (% farmers reporting resistance)																					
Resistant to Blast		70.18			10.53		4.35	7.69		10.00			75.00			100.00					

Resistant to Planthoppers	26.32		44.74	4.35	7.69	7.69		50.00
Resistant to Leaffolder	14.04							
Resistant to Rust				4.35		15.38		
Resistant to Panicle Disease	1.75							
Resistant to Neck Blast	2.63				7.69	7.69		
Resistant to Dom Van	1.75	1.08			7.69		14.29	
Resistant to Diseases							14.29	

1: Identifiers relate to villages/group in Figure 2, 'v' and 'g' denote villages and village groups, respectively. 2: 'C' = conventional, 'EE' = ecological engineering

Table S8: Use of resistant rice varieties according to interviewed farmers

Village ¹	Farm Type ²	Farmers (%) Planting Disease Resistant Varieties	Farmers (%) Planting Pest Resistant Varieties	Farmers (%) Rotating Varieties Between Seasons	Varietal Richness at Villages
v1	C	11.11	0.00	0.00	4
	EE	5.56	27.78	11.11	9
v2	C	30.00	0.00	0.00	3
	EE	0.00	0.00	0.00	2
v3	C	0.00	0.00	0.00	2
	EE	9.09	0.00	0.00	2
g4	C	16.13	29.03	19.35	3
	EE	41.38	89.66	3.45	4
v5	C	13.33	20.00	33.33	6
	EE	28.57	28.57	28.57	8
v6	C	0.00	0.00	83.33	6
	EE	50.00	33.33	83.33	6
g7	C	15.38	7.69	61.54	7
	EE	0.00	8.33	25.00	6
v8	C	15.79	26.32	94.74	4
	EE	11.00	18.18	9.09	4
v9	C	68.42	47.37	10.53	6
	EE	36.36	45.45	9.09	4
v10	C	23.81	19.05	76.19	8
	EE	33.33	22.22	66.67	5
v11	C	20.00	100.00	0.00	2
	EE	0.00	100.00	0.00	2
g12	C	60.00	40.00	15.00	5
	EE	60.00	30.00	10.00	6

1: Identifiers relate to villages/village groups in Figure 2, 'v' and 'g' denote villages and village groups, respectively. 2: 'C' = conventional, 'EE' = ecological engineering.

Table S9: Biotic constraints reported by farmers for each surveyed season

Farm-Type Season ¹	Conventional			Ecological Engineering		
	1	2	3	1	2	3
None	10.67 (10.67)	5.33 (5.33)	10.00 (10.00)	2.67 (2.67)	2.67 (2.67)	3.33 (3.33)
Rice Blast	45.00 (70.00)	56.00 (80.67)	41.00 (72.00)	19.00 (48.00)	29.00 (51.00)	27.00 (47.00)
Leaffolders	14.67 (35.33)	19.33 (48.00)	20.67 (45.33)	13.33 (31.33)	14.67 (46.00)	12.67 (42.67)
Planthoppers	6.00 (22.00)	12.00 (38.00)	4.67 (24.00)	2.00 (11.33)	12.00 (38.67)	6.00 (18.00)
Panicle mite	2.00 (12.67)	2.00 (23.33)	8.00 (40.00)	2.67 (12.00)	1.33 (3.33)	2.67 (25.33)
Bacterial blight	8.00 (19.00)	5.00 (17.00)	7.00 (18.00)	6.00 (15.00)	1.00 (8.00)	6.00 (13.00)
Rodents	6.67 (15.33)	4.00 (9.33)	6.67 (15.33)	12.00 (15.33)	6.00 (10.00)	6.67 (9.33)
Sheath Rot	0.00 (36.67)	2.00 (10.00)	1.33 (16.00)	4.00 (11.33)	4.00 (10.00)	1.33 (10.00)
Stemborers	1.33 (6.67)	0.00 (6.00)	2.67 (10.00)	2.67 (10.00)	1.33 (5.33)	1.33 (9.33)
Thrips	4.67 (6.00)	1.33 (4.00)	6.00 (7.33)	2.67 (5.33)	1.33 (1.33)	6.00 (8.67)
Whorl maggot	2.00 (4.00)	2.67 (4.67)	1.33 (3.33)	6.00 (6.00)	2.00 (2.00)	2.00 (2.00)
Golden Apple						
Snail	2.67 (3.33)	0.67 (2.67)	2.67 (3.33)	0.67 (3.33)	1.33 (3.33)	2.67 (4.00)
Caseworm	0.00 (2.00)	3.33 (5.33)	1.33 (2.67)	1.33 (4.67)	0.67 (2.00)	0.67 (3.33)

Numbers indicate the percentage of farmers reporting each pest or disease as a main constraint (rank = 1), with the percentage reporting the pest or disease as an occurring constraint (rank = 1 to 5) indicated in parentheses. 1: seasons 1, 2 and 3 refer to đông xuân (winter-spring, harvested around February), hè thu (harvested around June/July) and mùa thu (harvested around October)

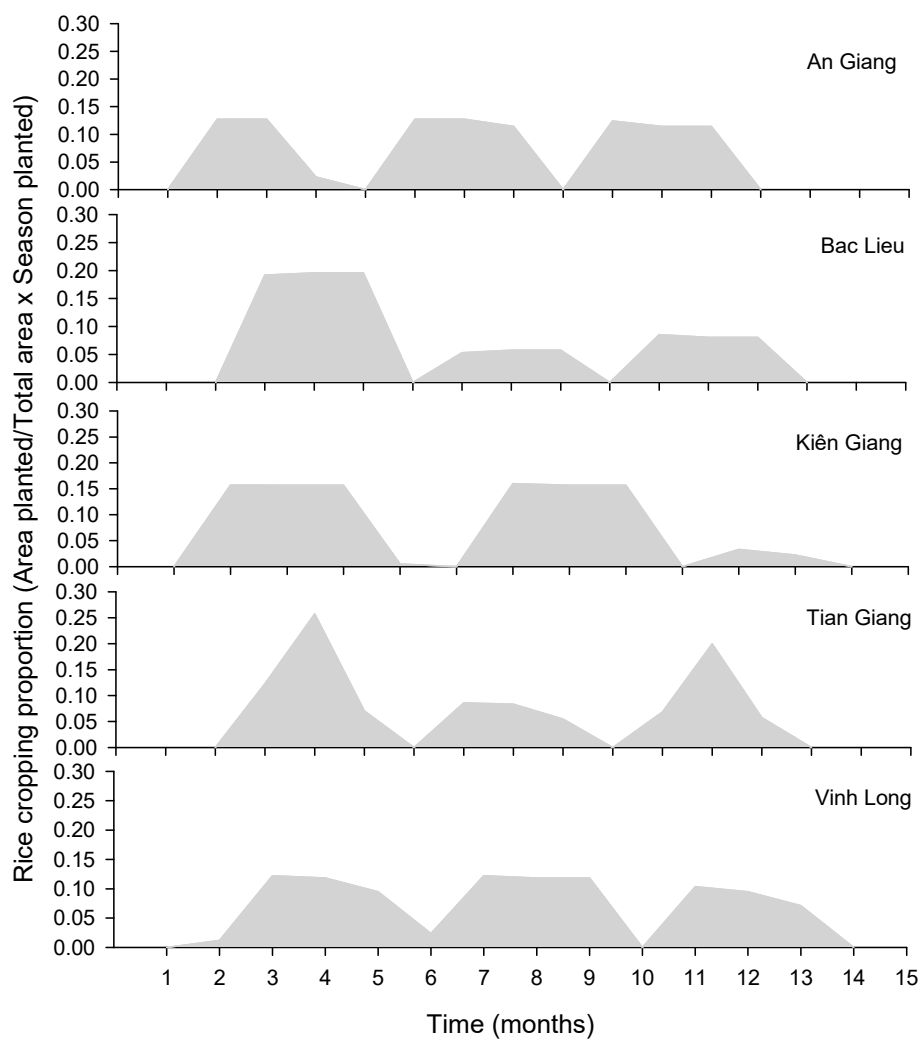


Figure S1. Rice cropping at sites in the MDR of Vietnam based on farmer reported planting and harvesting dates. Cropping patterns for each province are indicated because patterns were largely similar between villages within provinces. Months are indicated from September 2014 (1) to December 2015 (15).