Integrated Pest Management in Rice

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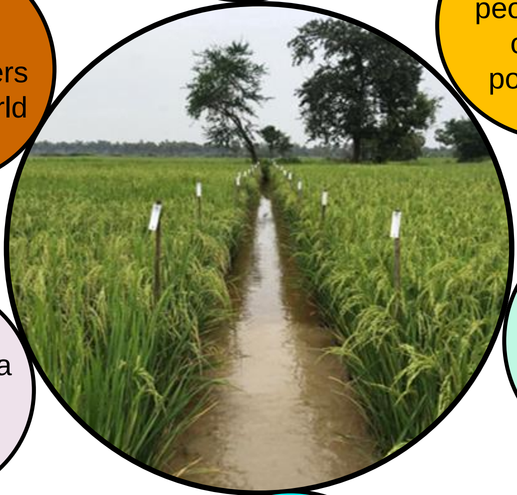
The importance of rice

Grown by 144 M farm families (25% of world farmers)

Feeds 4 B people (56% of world population)

Yearly uses25 M tons fertilizers (15% of world total)



Rice production increase by 25% the next 25 years

Harvested from 157 M ha (8% of world crop Land)

Yearly receives 880 km3 irrigation water (35% world total)

Rice will have to be produced, processed and marketed in more sustainable way, despite the diminishing resources (land, water, labor and energy).

Source: Bas Bouman and Lanie Reyes, 2017; Bas Bouman, 2017(RiceToday)
Photo credits: Chhourn Orn, CARDI

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Rice growing challenges

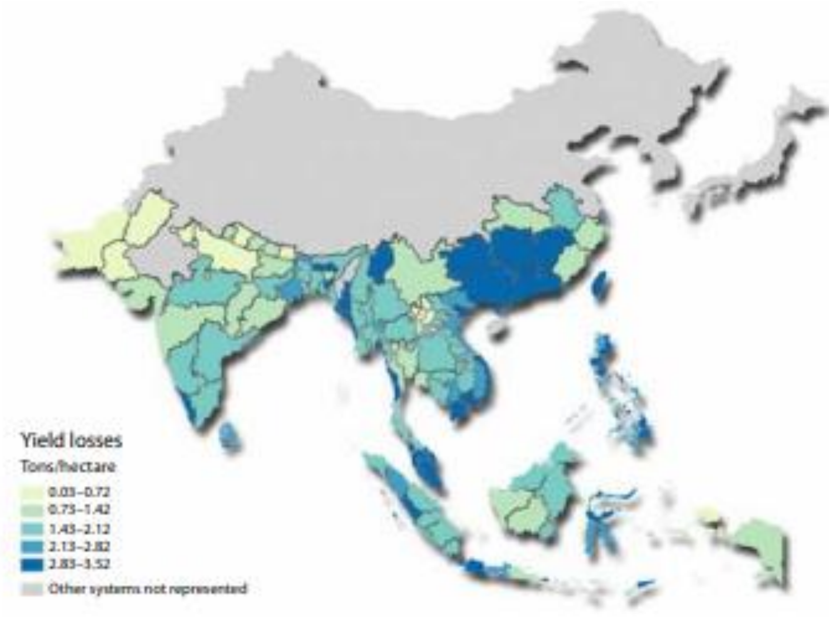


Fig. 1. Average predicted annual yield losses caused by pests and diseases in South and Southeast Asia.

Planthopper

Stemborer

Bacterial Blight

Fungal Blast

On average, farmers are estimated to lose 37% of their rice yield to pests and diseases.

Source: Adam Sparks, Andrew Nelson, Nancy Castilla 2012 (RiceToday)
IRRI RiceKnowledgeBank

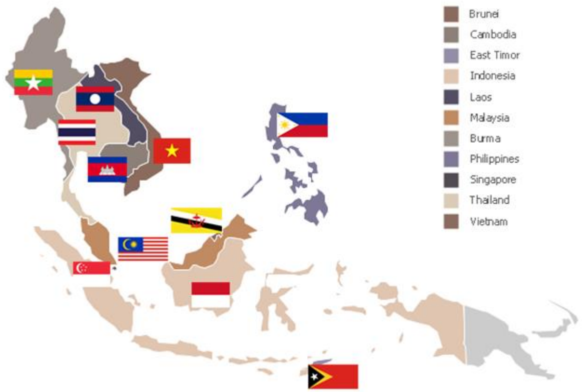
Integrated Pest management (IPM): a new paradigm

Earlier models of IPM focused on ecological aspects of pest management.

A new model of IPM based on ecological, economical, management, business, sustainability aspects and emphasizes the importance of research and outreach.

Dara, 2019 – Journal of Integrated Pest Management

IPM in Southeast Asia: key challenges



CHEMICAL MANAGEMENT

Intensive & insufficient control of pesticides.

The most available pesticides are broad-spectrum & high risk products.

No regulations on industrial & consumers chemicals.

Rapid expansion of pesticide trade.

OUTREACH

Lack of sufficient knowledge, awareness, resources and economic benefit.

Interaction patterns and financial arrangements among farmers, pesticide sellers and laborers sustain intensive use of pesticides.

Source: FAO Report 2019; Dara, 2019; Winarto, 2004; Flor et al, 2019, Schreinemachers et al., 2015.

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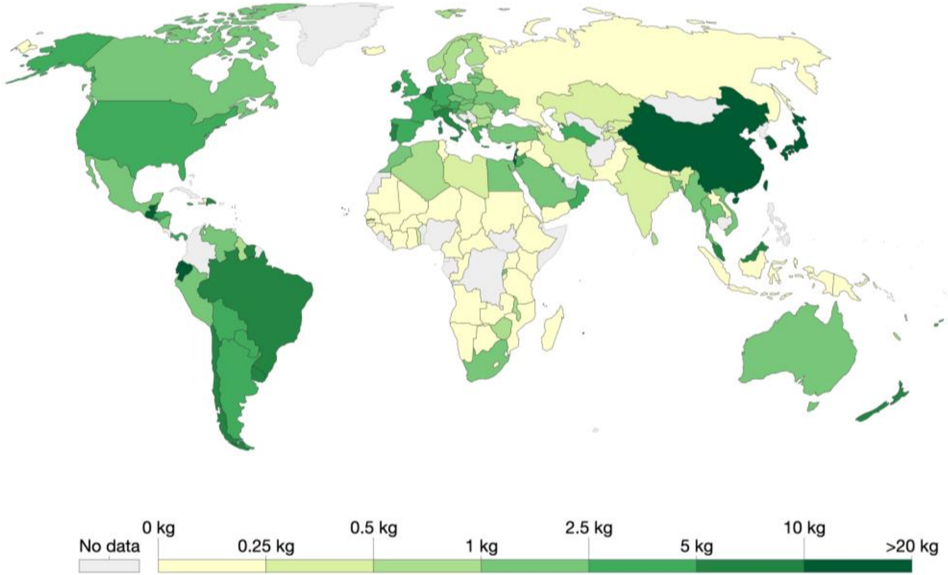
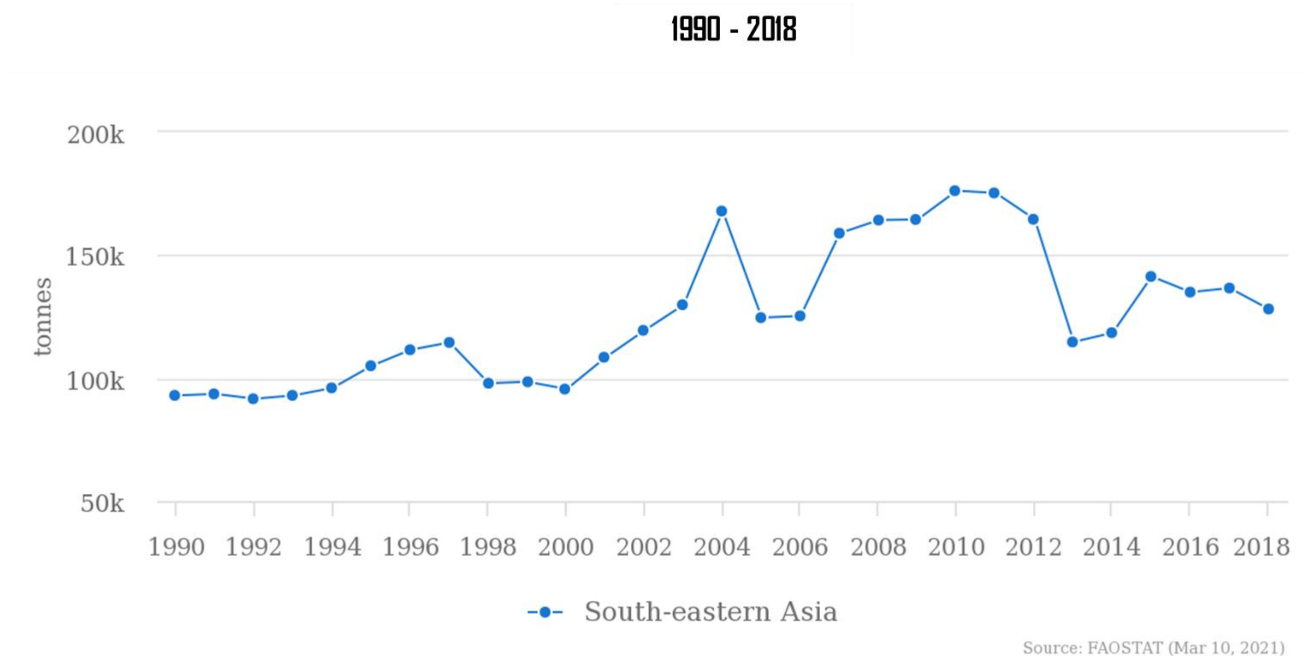
Pesticide use in the world

Pesticide use per hectare of cropland 1990 - 2017

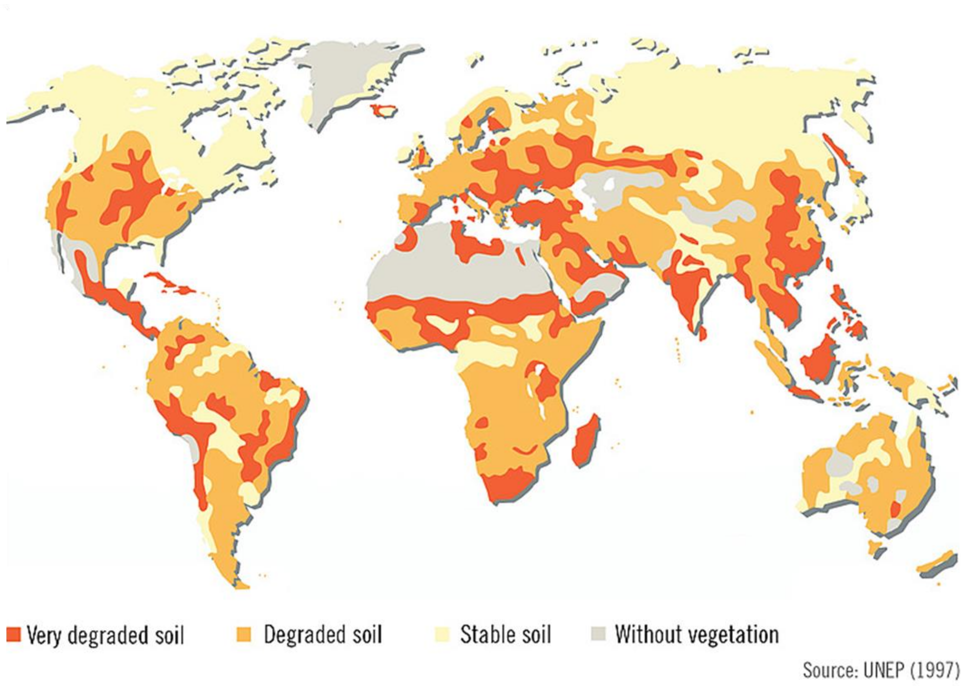


Source: FAO stat 2017,
Our world in Data.

IPM in Southeast Asia: key challenges



Soil degradation in the world



Biodiversity Management: advantages




- Enhancing natural enemies
- Provisioning of resources like nectar/pollen
- Suppression of rice pest
- Benefical for farmers
- Reduction of chemical input
- Increasing landscape heterogeneity

Gurr et al. (2004), (2009); Mitsch (2012)
Pics: Rica Flor, istockphoto

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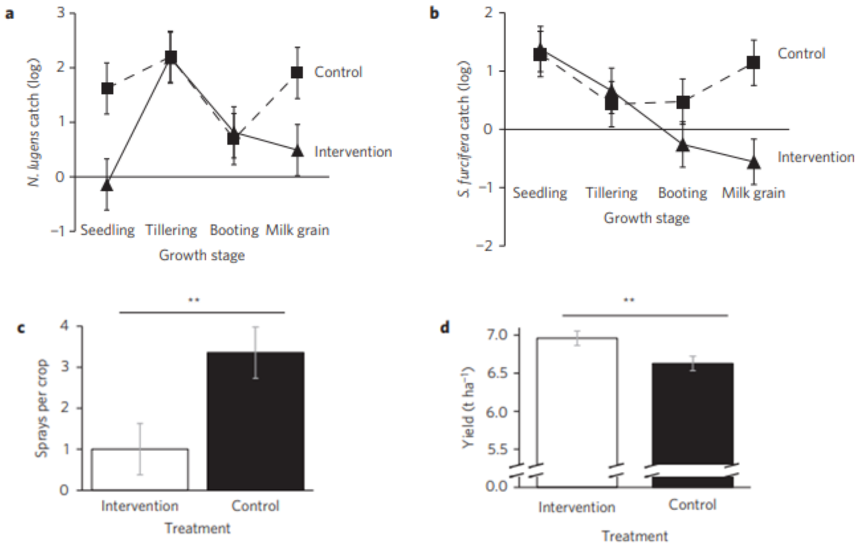
Biodiversity Management: multi-country evidence

Multi-site field study replicated in **Thailand**, **Vietnam**, **China** over 4 years period.



Nectar-producing plants were grown around the **rice fields**. Levels of pest infestation, insecticide use and yields were monitored.

- Reduced population of two key pests, brown planthopper *Nilaparvata lugens* and white backed planthopper *Sogatella furcifera*.
- Reduced insecticide applications by 70%.
- Increased grain yields by 5% and delivered economic advantage of 7.5%.

Gurr et al., 2016 (Nature Plants)

Biodiversity Management - Philippines

Vegetation strips

Weeds

Sesame

Okra

Mungbean

Fertilizer levels

0, 60, 150 kg N ha-1

Varietal resistance

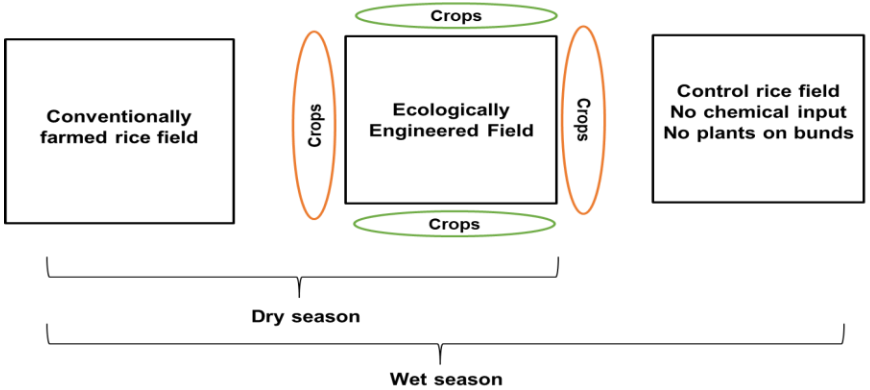
IR62, PH resistance

IR64 PH susceptible

- Parasitoids and predators of lepidopteran pests and of the ricebug were more abundant in high-nitrogen rice plots where their prey/hosts also had the highest densities.
- Weedy and sesame/okra bunds provided habitat for a range of natural enemies including spiders, parasitoids, predatory bugs.
- Varietal resistance and mung bean strips had an additive effect in reducing abundance of the planthopper *Sogatella furcufera* and the leafhopper *Nephotettix virescens*.

Horgan et al., 2019 (Insects)

Biodiversity Management - Cambodia



Mung bean (*Vigna radiata*)

Sesame (*Sesamum indicum*)

Sponge gourd (*Luffa aegyptiaca*)

Chilli (*Capsicum annuum*)

Sattler et al. 2021

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Farmers participatory study

Gender-informed survey and bund plants

Table 1. Top selected crops by surveyed famers (n = 60).

Rank	Common Name	Scientific Name	n	% of Respondents
1	Rice	*Oryza sativa*	59	98.3
2	Sponge gourd	*Luffa aegyptiaca*	54	90.0
3	Lemon grass	*Cymbopogon* sp.	49	81.7
4	Banana	*Musaacuminata*	48	80.0
5	Papaya	*Carica papaya*	46	76.7
6	Greater galangal	*Alpinia galanga*	40	66.7
7	Mango	*Mangifera indica*	39	65.0
7	Chili	*Capsicum annuum*	39	65.0
9	Coconut	*Cocos nucifera*	38	63.3
9	Turmeric	*Curcuma longa*	38	63.3
11	Bottle gourd	*Lagenaria siceraria*	32	53.3
11	Chinese basil	*Ocimum basilicum*	32	53.3
13	Sweetsop/sugar apple	*Annona squamosa*	30	50.0
13	Sugar palm tree	*Borassus flabellifer*	30	50.0

Prey Veng province: 30 female + 30 male farmers

- Short growing duration
- Flowers in time with the rice growing period
- Could grow on rice bunds

During the survey, most farmers stated not willing to cultivate bund crops.

Benefit cost ratio of treatments

Partial benefit–cost analysis (in USD ha^{-1}). To compute the benefit–cost ratio (BCR) only paid-out costs were considered, which excluded the labor costs of the farmer or farm household.

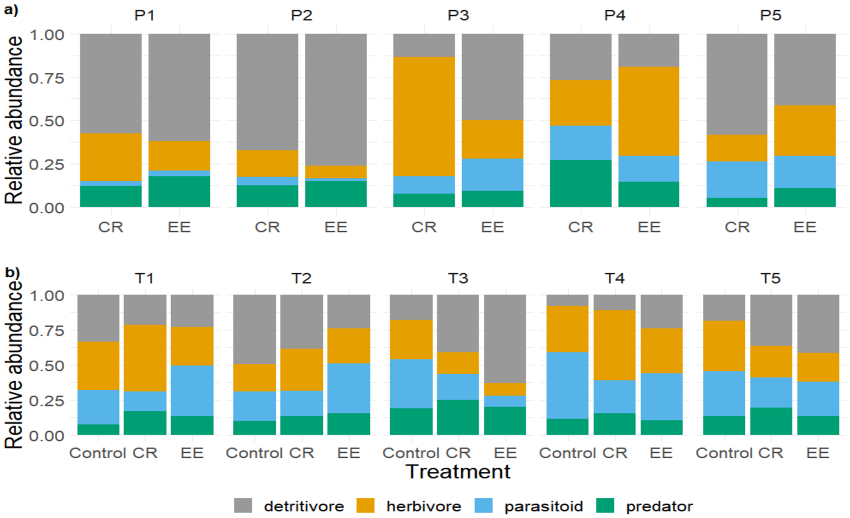
	Ecological Engineering (*n* = 5)				Control (*n* = 5)				Conventional (*n* = 5)			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Land preparation (constant)	459.2	459.2	459.20	0.00	459.2	459.2	459.20	0.00	459.2	459.2	459.20	0.00
Seed cost (rice)	115.0	115.0	115.00	0.00	115.0	115.0	115.00	0.00	115.0	115.0	115.00	0.00
Seed cost (crop)	2.0	2.0	2.0	0.00								
Labor	25.0	25.0	25.00	0.00	0.0	25.0	12.00	12.55	0.0	25.0	5.00	11.18
Fertilizer	19.01	83.00	46.35	24.48	19.01	56.25	43.43	16.51	19.01	78.75	53.18	21.67
Pesticide	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00	11.75	46.00	31.25	17.63
Pest mgmt. labor	0.0	0.0	0.0	0.00	0.0	0.0	0.0	0.00	3.0	25.0	15.20	11.32
Harvest (constant)	63.4	63.4	63.40	0.00	63.4	63.4	63.40	0.00	63.4	63.4	63.40	0.00
Total cost	683.61	747.60	710.95	24.48	656.61	718.85	693.03	27.57	672.11	787.35	742.23	48.47

	Ecological Engineering (*n* = 5)				Control (*n* = 5)				Conventional (*n* = 5)			
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD
Revenue rice	1125.00	1580.63	1372.50	164.86	1338.75	1490.63	1402.88	68.73	1046.25	1603.13	1366.88	202.54
Revenue mung bean	2.50	76.67	35.17	25.74								
Revenue sponge gourd	1.56	6.67	5.12	1.88								
Revenue sesame	4.69	54.17	23.84	17.86								
Total revenue	1133.75	1718.14	1436.63	153.79	1338.75	1490.63	1402.88	68.73	1046.25	1603.13	1366.88	202.54
BCR	1.66	2.30	**2.02**	0.19	1.94	2.09	**2.02**	0.06	1.56	2.07	**1.84**	0.19

n = number of rice fields.

- Conventional rice fields has the highest cost, due to labor costs of pesticide and pest management.
- Benefit-cost rations were similar for ecological engineered (EE) and control, followed by conventional rice.

Predators and detritivores mostly higher in ecological engineered (EE fields), herbivores (pests) were lower



Relative abundance of functional groups per rice field collected in different treatments (CR= conventional rice field, EE= ecological engineered field, Control).

*Rice fields were compared in pairs (P1-5) during the a) dry season and compared in trios (T1-T5) during the b) wet season.

Sattler et al. 2021

Management of disease: the use of beneficial microbes

Rice blast

Comparison of area under leaf blast progress curve (AULBPC) at two different sites and different seasons with or without *Trichoderma harzianum* treatment (Td).

Location	Season	Year	Total Sample size	CAR14 no Td	CAR14 with Td	IR504 no Td	IR504 with Td	Conventional practice
Koktrap	wet	2016	30	664.71 ± 151.05a	502.83 ± 235.71a	1058.26 ± 152.42a	863.81 ± 143.82a	
Polors	wet	2016	30	548.27 ± 10.79 b	493.49 ± 37.14 b	1042.23 ± 85.24 a	964.89 ± 13.45 a	
Polors	dry	2017	40	238.77 ± 10.35 a	233.05 ± 130.96 a	352.00 ± 97.50 a	372.28 ± 69.41 a	387.21 ± 54.87 a
Koktrap	wet	2017	40	169.34 ± 23.82 c	99.65 ± 11.55 c	517.58 ± 42.04 a	339.97 ± 46.29 b	477.72 ± 61.57 a
Polors	wet	2017	40	184.73 ± 45.48 c	113.64 ± 30.75 c	607.31 ± 21.39 a	383.78 ± 42.91 b	367.82 ± 17.61b

Data are mean ± SD. Different alphabetical small letters in the same line indicate a significant difference ($p < 0.01$, Tukey-Kramer multiple comparison test). Sample size and number of replications are described in Table 1. Average 43.29 leaves per sample were assessed.

Resistant/ Susceptible varieties

Trichoderma harzianum

- CAR14: resistant variety; IR14: susceptible variety.
- Application of *T. harzianum* does not affect pathogen infection on a resistant variety but it can significantly reduce the pathogen infection on a susceptible variety, but the efficacy is not consistent.

Chou et al., 2020 (Crop Protection)

IRRI RiceKnowledgeBank
Pics: Cornell.edu, dreamstime

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Adoption of best practices

A national program in Vietnam: “1 Must Do and 5 Reductions (1M5R) started in 2003

- “1 Must Do” regards the use of certified seed.
- “5 **Reductions**” regards to seed, water, fertilizer, **pesticide** use and post-harvest losses”

- Parallel initiative: establishment of sustainability and certification standards for rice production.

- Develop a system to obtain a price premium for sustainably produced rice.

Flor et al., 2021 (Agronomy)

Adoption of best practices

A large-scale program of Sustainable Agricultural Transformation (VnSAT) in Vietnam started in 2015

Province.	Three Reductions, Three Gains			One Must Do, Five Reductions			Percentage Increase in Income (VnSAT Farmers vs. Non VnSAT Farmers)
	Number of Farmers Trained	Area Covered in Training (ha)	Area with Farmers Adopting 3R3G (ha)	Number of Farmers Trained	Area Covered in Training (ha)	Area with Farmers Adopting 1M5R (ha)	
An Giang	18,833	25,417	20,969	18,833	25,417	19,851	26.4
Cần Thơ	25,435	31,794	26,997	17,805	22.256	17,263	34.6
Đồng Tháp	18,624	31,657	24,232	8,829	15,207	11,541	27.5
Hậu Giang	21,645	21,976	18,677	14,278	14,680	13,586	25.8
Kiên giang	19,240	31,927	24,394	9,654	16,917	11,165	30.3
Long An	11,835	29,440	22,220	10,866	28,606	18,653	29.0
Sóc Trăng	16,746	22,329	20,106	13,351	15,598	13,712	18.9
Tiền Giang	23,422	19,123	17,847	10,832	8201	8099	36.4
Total	155,780	213,663	175,442	104,448	124,648	113,870	

Source: VnSAT Workshop on implementation progress, monitoring and evaluation on 26 May 2018, Can Tho City and 15 December 2021, Hanoi, Vietnam.

- The adoption of 1M5R strengthened the economic status of smallholder farmers.
- Provide a strong platform for promoting sustainably produced rice.

Flor et al., 2021 (Agronomy)

Take home messages

- Diversification of rice-based systems in combination with farmers' choice of crops is a promising solution of insect herbivores management and provide additional income and yield for farmers.
- Beneficial microbes can improve disease resistance of susceptible variety under certain conditions and more understanding on conditions that increase its efficacy is needed.
- Social aspects can be a challenge for implementation of IPM technologies.
- Research and outreach are fundamental for implementation of IPM technologies in the fields.

Pics: Rica Flor

Thank you!

Pics: Rica Flor

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