Bringing about a sustainable agronomic revolution in rice production in Asia by reducing preventable pre- and postharvest losses (RETA 6489)

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Annual Report

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Bringing about a sustainable agronomic revolution in rice production in Asia by reducing preventable pre- and postharvest losses
RETA No. 6489

Component 1: Reducing vulnerability of crops to preharvest losses caused by planthopper outbreaks, "Rice Planthopper Project"

Annual Report 2009

Chapter 1: Introduction

The project started in November 2008 with partners from China, Thailand, and Vietnam. The inception workshop was held on 3-5 November 2008 in Ho Chi Minh City and a follow-up consultation workshop was held in Bangkok with the Thai partners on 19-21 January 2009 in the Rice Department.

In 2009, planthopper outbreaks were reported in many countries in Asia (Fig. 1.1). The most seriously damaged areas were the Central Plains of Thailand and northern Vietnam-Yunnan of China. BPH damage in Thailand caused the government to revise its production forecast by 16% from 8.3 million to 7 million tons (http://ricehoppers.net/2010/01/28/thailand-cuts-second-crop-rice-output-forecasts-by-16-because-of-bph-and-water-shortage/). Thousands of farmers lost their crops and the Thai government released 2 billion baht (US$60.5 million) to compensate farmers for their losses. The amount to be given per farm was hardly sufficient to support land preparation for the next crop. In addition, the government also released approximately $1.8 million for free pesticide distribution.

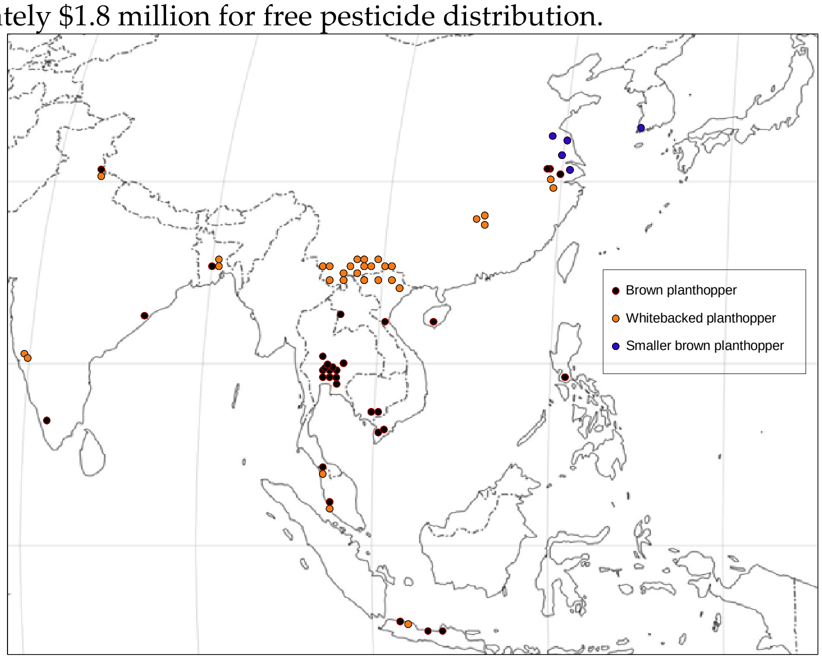
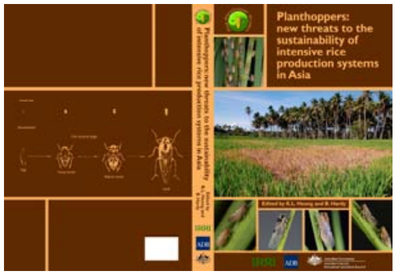


Fig. 1.1 Distribution of planthopper outbreaks that occurred in 2009.

From November 2008 to December 2009, the following activities were undertaken:

1. A review of planthopper resistance mechanisms was completed.
2. A new, more efficient method of culturing planthoppers was established.
3. Research on epidemiology of planthopper-transmitted viruses continued.
4. Baseline farm surveys on farmers' knowledge, attitude, and practice (KAP) on planthopper management and ecological engineering were completed in China (Guilin, Jin Hua), Thailand (Chainat), and Vietnam (Cai Be, Cai Lai).
5. Four ecological engineering pilot sites were established in Guilin, Jin Hua, Cai Be, and Chainat.
6. Monitoring of insecticide resistance continued at 6 locations.
7. Training of researchers on "Decision Making and Sociological Research Tools" in three countries was completed.
8. In-country training of enumerators and research partners on survey procedures, questionnaire pretesting, and data entry in China, Thailand, and Vietnam was completed.
9. Training of researchers on "Ecological Engineering and Research Methods" was completed.
10. Training of researchers on "Toxicology and Insecticide Resistance Monitoring" was completed.
11. Establishment and maintenance of the Rice Planthopper Project blog continued.
12. Established the China-IRRI-Vietnam consortium for planthopper and virus research to focus on the new virus problem, southern rice black streak dwarf virus (SRBSDV) carried by the whitebacked planthopper (WBPH).
13. Leveraged national support in rice planthopper research (approx. US$6.4 million)
    a. China. A 973 grant of 30 million yuan (approx. $4.4 million) for 5 years from the Ministry of Science and technology (MOST).
    b. China. A grant of 1 million yuan (approx. $150,000) from the Natural Science Foundation for China-IRRI collaboration on planthopper research.
    c. Thailand. A 58 million baht grant (approx. $1.8 million) from the Ministry of Agriculture for 3 years to develop sustainable strategies to manage planthopper outbreaks.
    d. Thailand. A 1 million baht grant (approx. $30,000) to expand ecological engineering at 10 sites in Uthai Tani Province.
14. The book titled "Rice planthoppers: threats to the sustainability of intensive rice production systems in Asia," edited by K.L. Heong and Bill Hardy, will be printed and available in mid-March 2010.

    Book cover



This annual report discusses project activities, results, and main achievements from November 2008 to December 2009.

Chapter 2: Summary of Major Activities

2.1 Output 1: New field resistance screening method and germplasm with durable field resistance to planthoppers and virus diseases identified for incorporation into new elite breeding lines and mega-varieties

Activity 1.1. Determine key ecological fitness characteristics and chemical basis

Our understanding of the interactions between planthoppers and rice is improving due to a series of novel experiments conducted during 2009. Furthermore, our results indicate that major changes are required in the methodologies and implementation around host-plant resistance technologies.

Following a series of critical reviews ("Mechanisms of resistance: a major gap in understanding planthopper-rice interactions" by F.G. Horgan; "Planthopper 'biotypes' " by F.G. Horgan and J. Ferrater; and "The genetics of hopper resistance" by F.G. Horgan, D. Fujita, J. Ferrater, and A. Kohli), we have identified a number of areas where current paradigms are flawed and potentially inhibit or limit progress in the development of resistant varieties. During 2009, we invited a number of experts to participate in preparing a book to address these issues. The book titled "New Paradigms in Hopper Resistance" is designed to aid researchers and their institutes in developing and deploying resistant varieties.

New BPH colonies have been established at IRRI. These colonies with founder populations from seven locations will help achieve better replication of screening and other experiments. Already, experiments using these colonies have indicated a worrying loss of effectiveness of resistance genes. It appears that planthoppers have now adapted to a large proportion of those genes for which markers are available. Furthermore, virulence varied considerably between populations, indicating that some populations may be affected less by migration and mixing.

Using green leafhopper (GLH) as a model and with materials provided by Kyushu University (Japan) that include NILs and PYLs for a series of resistance genes, we have determined that certain genes, despite a lack of apparent effect when they occur alone in a plant (monogenic NIL), can result in significant resistance when combined in PYLs (see Fig. 2.1.1).

This suggests that some of the defunct genes for resistance to BPH could still function when combined in pyramided lines. However, we will determine whether durability of such pyramided resistance is compromised by the inclusion of a "weak" or "defunct" gene.

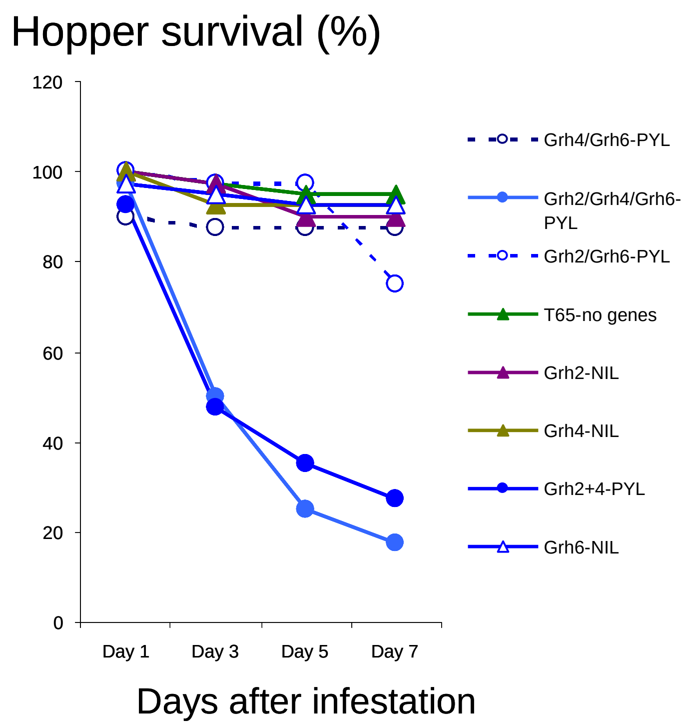


Fig. 2. 1.1. Rice resistance to GLH in NILs and PYLs with known resistance genes. Note that monogenic Grh2, Grh4, and Grh6 lines have no effect on nymphal survival, whereas, when genes are combined (PYLs), survival declined significantly.

A large experiment to examine heterosis for resistance in hybrid rice varieties has been completed. This has resulted in a very large database that is currently being analyzed. Data on plant characteristics and insect performance have been compiled. The insects used in the experiments were BPH, WBPH, and YSB. Counting of BPH and WBPH continues. The results so far indicate a higher susceptibility of hybrid plants to YSB that is linked to the restorer lines, whereas, in BPH, the restorer lines were the least susceptible to damage (Figs. 2.1.2 & 2.1.3).

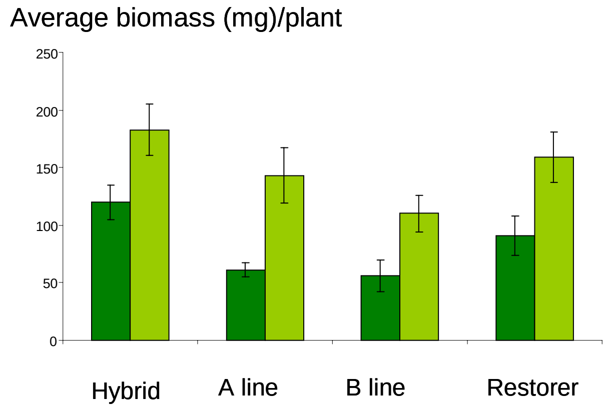


Fig. 2.1.2. YSB biomass on hybrids and their parental lines. Dark green is without added nitrogen, light green has nitrogen added. Restorer and hybrid lines tended to favor YSB.

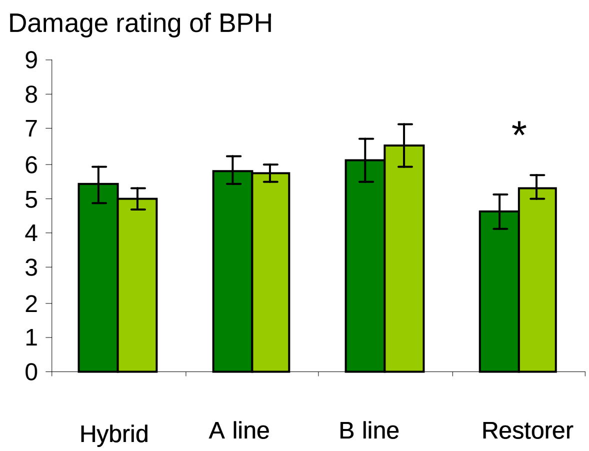


Fig. 2.1.3. Damage on plants due to BPH. The restorer lines had significantly less damage. Dark green is without added nitrogen, light green has nitrogen added.

A new experiment to examine the effects of relative growth rates on tolerance and resistance has begun using 32 varieties that include a range of hybrids (22) and inbreds (10) that are among the most widely grown varieties in Asia and South America. These varieties will be challenged with WBPH, BPH, and YSB in greenhouse experiments. Insect fitness parameters will be examined against plant characteristics adhering to phylogenetic distances (genetic correlates). In field planting, varieties have been assessed for insect damage also. Preliminary field screening results are presented (Fig. 2.1.4).

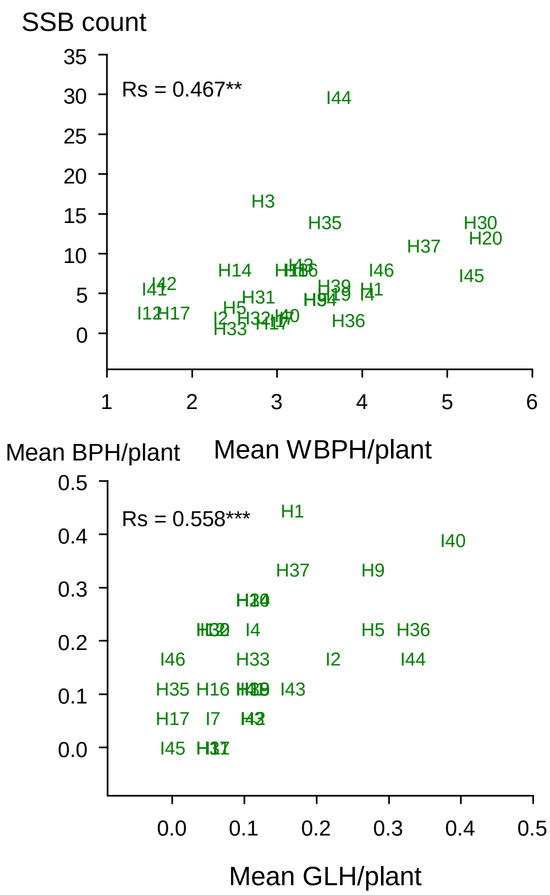


Fig. 2.1.4. Correlations between striped stem borer (SSB) damage and incidence of WBPH among 32 popular rice varieties, with corresponding correlations between BPH and GLH in the same plots. H = hybrid variety, I = inbred.

Activity 1.2. Develop an improved screening method to identify durable resistance genes

During 2008 and 2009, we bulked up seeds at IRRI for future experiments. Sufficient seed was required to test differential varieties using a series of fitness tests. Furthermore, enough seed was required to maintain hopper populations for several generations to test resistance durability. We developed an improved method for rearing colonies and have sent indications to our NARES partners on how to improve colony maintenance.

We have completed a first run of a large study to evaluate screening methods. In the greenhouse, we have tested 16 differential varieties with known resistance genes and/or known mechanisms using several tests.

Tests included SSST and SSST controls, MSST-7.4 and controls, MSST-20-8 and controls, days to wilt test, ovicidal test, nymphal survival tests, and fitness tests (including honeydew evaluations). All tests, with the exception of the ovicidal test, have corresponding controls. Observations on the logistics, time, and monitory costs of the tests have been recorded also.

A protocol has been prepared and sent to NARES partners and data sheets provided in EXCEL. Currently, more than 18 institutes have expressed interest in participating in the trials, which will give useful information on the regional virulence of BPH populations (attached). Some preliminary results are presented in Figure 2.1.5. Results indicate that whereas the SSST results can be related to honeydew tests, they are not a good indicator of insect survival. BPH was more tolerant of the varieties than had been expected. This indicates the potential for BPH populations to overcome the resistance rapidly if varieties are not properly deployed.

During 2010, we planted seed from 56 varieties. Each variety contained some known BPH or WBPH resistance gene. These materials will be bulked up for future distribution to NARES partners. Based on the results of the previous tests, we will determine a suitable screening method to test these materials against local hopper populations. Together with our NARES partners, this activity will help determine regional hopper virulence and the best gene deployment strategies.

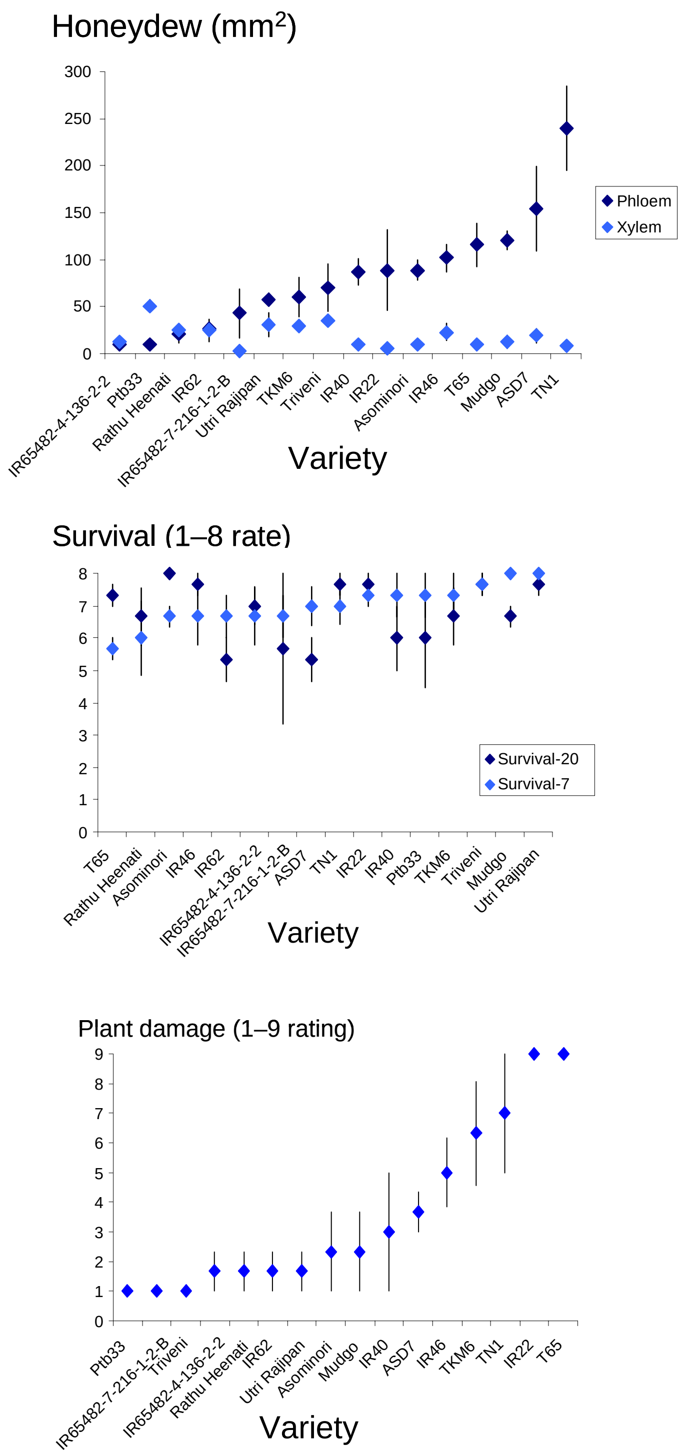


Fig. 2.1.5. Results of fitness tests on 16 differential varieties and susceptible check TNI. Note that whereas honeydew and damage ratings indicate some resistance against/tolerance of BPH, survival is generally high, suggesting widespread gene vulnerability (genes include *Bph1*, *bph2*, *Bph3*, *bph4*, *Bph10*, *Bph18*, and *Ovc*).

Activity 1.3. Screen selected cultivars using SSST and MSST

Because of poor resistance in previous tests, we have broadened our search for suitable resistant materials and for durable resistance. We are now screening lines based on marker-aided selection of *Bph3*, *Bph9*, *Bph10*, *Bph18*, *bph20*, and *Bph21*. We have also included in our screening new materials from ANGRAU-India that demonstrated high resistance in field trials in Marutera.

A questionnaire based on a series of focus group discussions (FGD) held at Iloilo in coordination with C. Arroyo, M.M. Escalada, and K.L. Heong will be distributed in 2010 (http://ricehoppers.net/2009/06/25/will-farmers-rely-on-varietal-resistance-to-combat-insect-attack/). A second questionnaire aimed at determining current screening practices and attitudes among entomologists and staff at international plant-improvement institutes will be distributed in 2010.

Activity 1.4. Develop isogenic lines and pyramid genes in elite lines

Marker-aided development of near-isogenic lines continues. Lines are now in the BC_4 stage and are being screened for effect and selection using a BPH Laguna population. This activity, which requires continued PCR screening for genes, is ongoing. Greenhouse screening was originally designed to support later-stage development of NILs; however, because of rapidly evolving virulence, greenhouse screening has become an essential component of this activity.

NARES partners and collaborators in Activity 1

CHINA
Dr. Yonggen Lou (professor), Institute of Insect Sciences, Zhejiang University
Dr. Lu Zhongxian, Institute of Plant Protection and Microbiology, Zhejiang Academy of Agricultural Sciences

JAPAN
Dr. Hideshu Yasui (plant geneticist), Kyushu University

PHILIPPINES
Corazon Arroyo, DA-WESVIARC, Hamungaya, Iloilo City

THAILAND
Dr. Jiapong Jairin (research officer), Ubon Ratchathani Rice Research Centre

VIETNAM
Dr. Luong Minh Chau (entomologist and head), Cuu Long Delta Rice Research Institute
Dr. Ngo Luc Cuong (entomologist), Plant Protection Department, Cuu Long Delta Rice Research Institute

Output A.2. Strategies to manage virus spread in rice fields developed and implemented at pilot sites

A. 2.1 Establish a procedure facilitating detection of RGSV and RRSV in plants and BPH from fields

- To establish the optimum conditions for serological detection of viruses transmitted by brown planthoppers (BPH), we examined various factors that may affect the sensitivity of the detection method.
- Samples prepared from the leaf blade and leaf sheath of rice plants infected with rice grassy stunt virus (RGSV) and rice ragged stunt virus (RRSV) were examined for the levels of detection to determine what part of plants is better for virus detection. The samples were examined by double sandwich antibody (DAS)-enzyme linked immunosorbent assay (ELISA). The results indicated that the leaf sheath is the better tissue to examine for virus infection than the leaf blade (**Fig. 2.2.1**).

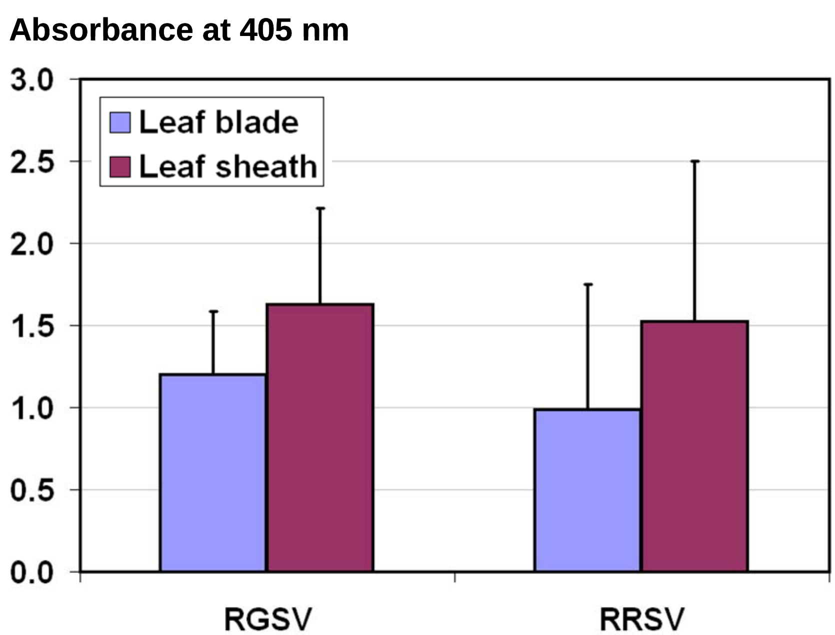


Fig. 2.2.1. Comparison between leaf blade and sheath for the detection of RSGV and RRSV by DAS-ELISA.

- It may sometimes take a few days to bring and examine plant samples collected from fields in a laboratory for virus infection. To assess the influence of transport/storage period on the detectability of virus by ELISA, the detection levels of viruses in rice leaves in sampling bags left in a refrigerator for different days after harvesting were examined. The results showed that detectability for RGSV is maintained for at least 10 days, while that for RRSV started decreasing immediately after harvesting (**Fig. 2.2.2**).

- Plant sap should be prepared from samples collected in fields for the detection of viruses by ELISA. Plant samples can be extracted by various methods. The levels of ELISA detectability for viruses in plant sap samples prepared by different methods were compared to determine the most proper method of sap extraction. For the detection of RGSV, the levels of detectability were not significantly different among the samples prepared with (1) leaf and bud press, (2) mortar and pestle, and (3) eppendorf tube (**Fig. 2.2.3**). However, detectability for RRSV by ELISA was highest in the samples prepared by the leaf and bud press (**Fig.2.2.3**).

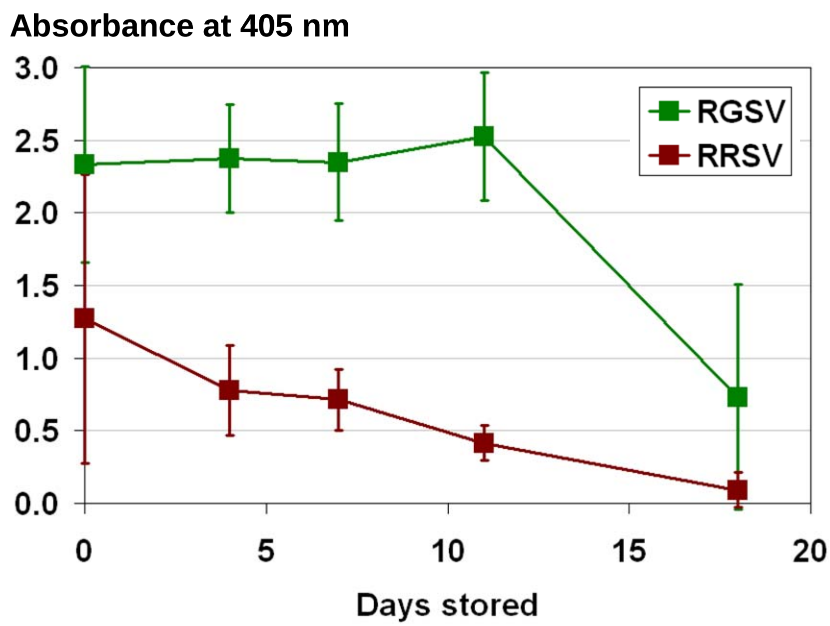


Fig. 2.2.2. Influence of storage period on levels of virus detection by DAS-ELISA.

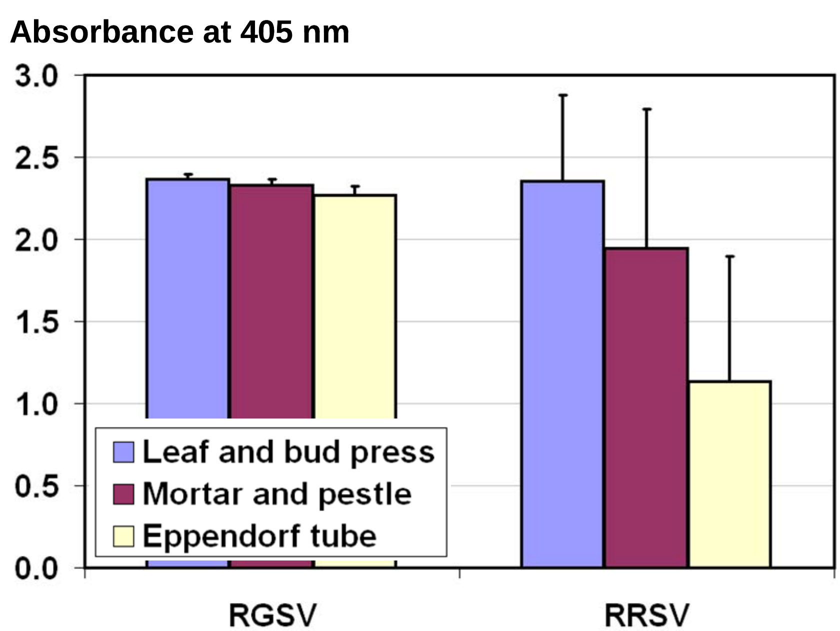


Fig. 2.2.3. Levels of ELISA detectability for RGSV and RRSV in plant sap samples extracted by different methods.

- Thus, various factors such as (1) freshness of samples, (2) parts of the plant sampled, and (3) methods of sap extraction may affect the detectability of ELISA for viruses in rice.
- To improve the sensitivity of ELISA for viruses, the ELISA procedure was modified by using biotinylated antibodies and avidin labeled with alkaline phosphatase. The sensitivity of biotin/avidin (B/A)-ELISA for RRSV was significantly higher than that of DAS-ELISA (**Fig. 2.2.4**).

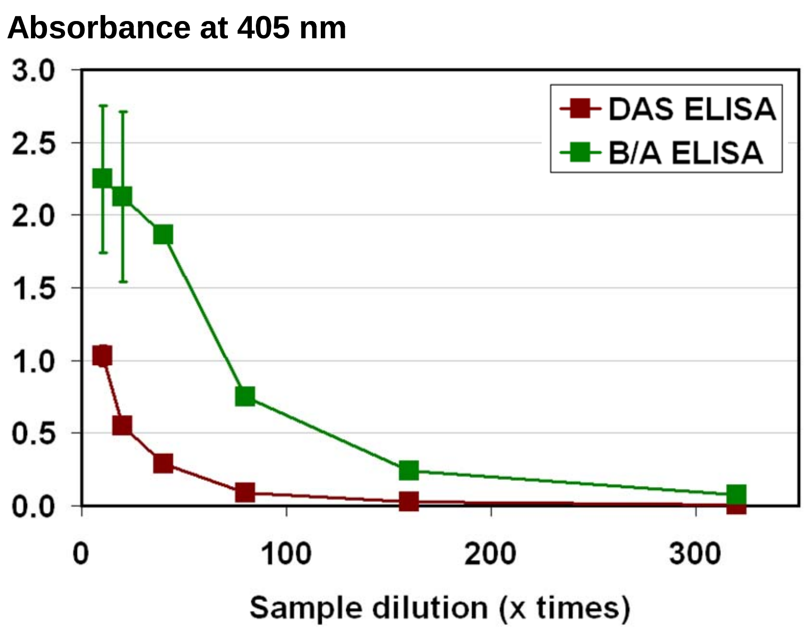


Fig. 2.2.4. Detection levels of RRSV contained in serially diluted sap samples by DAS-ELISA and biotin/avidin (B/A)-ELISA.

- Two training sessions on nucleic acid-based and immunology-based virus detection methods, one at IRRI for four Vietnamese researchers and another for ten Vietnamese researchers at the Southern Regional Plant Protection Center (SRPPC) in Tien Giang Province, Vietnam, were held in November of 2009, introducing the B/A-ELISA system (**Fig. 2.2.5**).

A. 2.2 Determine biological and genetic characteristics of viruses

- A survey for rice virus species prevalent in the Mekong Delta and plant species (rice and weeds) infected with the rice viruses was conducted between 10 and 24 March 2009.

- During the survey, it was observed that varieties such as IR50404, which were heavily infected by viruses during the peak of outbreaks in 2006-08, were still planted by farmers and affected by the viruses (**Fig. 2.2.6**).
- Types and levels of severity of disease symptoms varied among plants dually infected with RGSV and RRSV (**Fig. 2.2.7**A and B). Some plants showed only yellowing, bronzing, and stunting but no profuse tillering (plant 1 of **Fig. 2.2.7**B), whereas other plants showed profuse tillering typical of grassy stunt (plants 2 and 3 of **Fig. 2.2.7**B). Some plants also exhibited yellowing and serrated and twisted leaves without profuse tillering (plants 5 and 6 of **Fig. 2.2.7**B). The variation in symptoms might be caused by the difference in the timing and sequence of infection with RGSV and RRSV in the field.

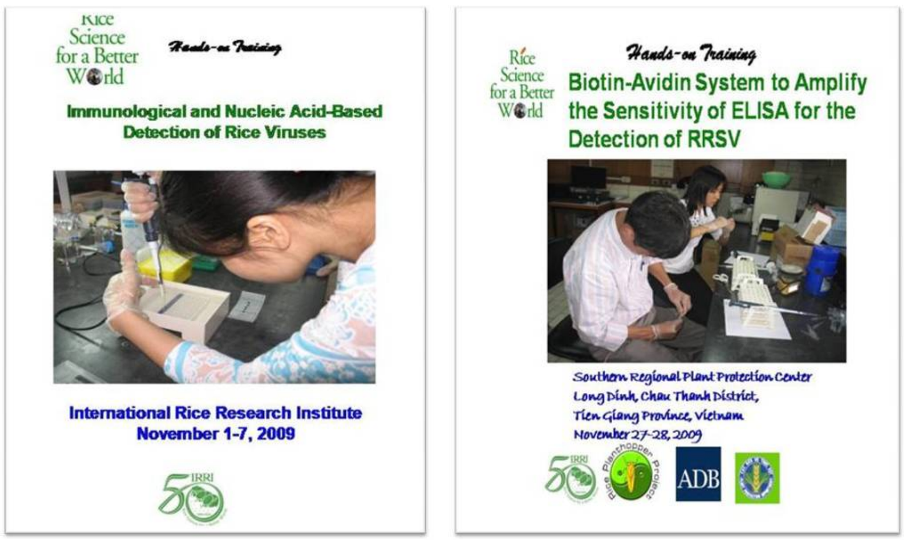
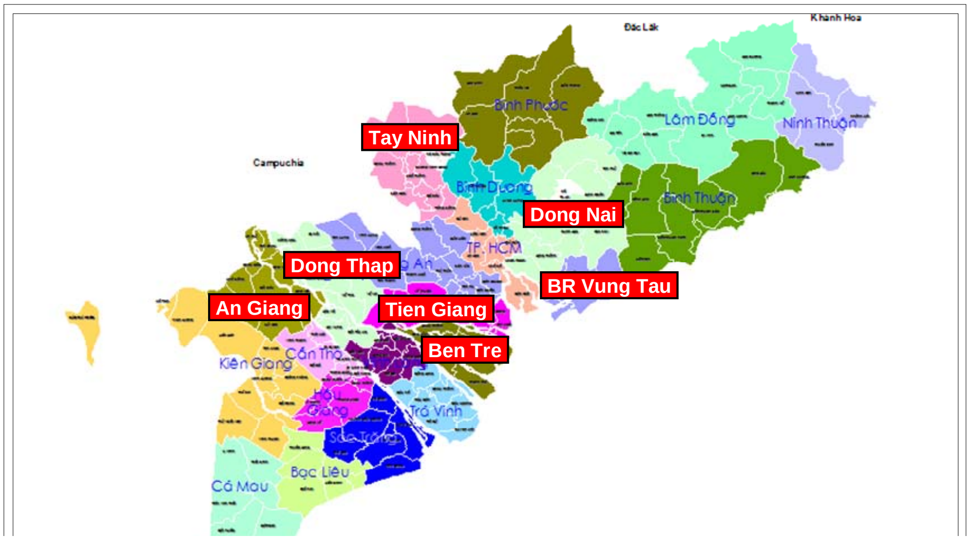


Fig. 2.2.5. Covers of resource materials used for training of Vietnamese researchers to introduce immunological and nucleic acid-based detection of rice viruses in November 2009.



Province	District	Village	Plant	Variety	Plants infected with / plants collected		
					RRSV	RGSV	RGSV + RRSV
Tien Giang	Chau Thanh	Long Dinh	Rice	HD1	5/5	3/5	3/5
Tien Giang	Chau Thanh	Long Dinh	Rice	IR50404	3/5	5/5	3/5
Ben Tre	Mo Cay	Tan Phu Tay	Rice	LD2161	10/10	9/10	9/10
Dong Thap	Cao Lanh		Rice	IR50404	3/5	5/5	3/5
Dong Thap	Thap Muoi	Long Bien	Rice	OMCS200	14/15	9/15	8/15
An Giang	Chau Phu	My Phu	Rice	OM4218	0/5	5/5	0/5
An Giang	Chau Phu	My Phu	Weeds		2/2	2/2	2/2
An Giang	Chau Phu	My Phu	Rice	OM2514	3/15	15/15	3/15
Tay Ninh	Hoa Tahnh		Rice		5/5	2/5	2/5
Tay Ninh	Hoa Tahnh		Rice		5/5	2/5	2/5
Dong Nai	Tan Phu	Phu Thanh	Rice	OM3536	15/15	10/15	10/15
BR Vung Tau	Xuyen Moc	Phouc Tan	Rice	OM4498	1/10	10/10	1/10

Fig. 2.2.6. Rice areas, virus species, and plants found infected with rice viruses surveyed in March 2009.

- Pure cultures of RGSV and RRSV in rice plants, and plants dually infected with RGSV and RRSV, were started and are now maintained at SRPPC for future research work on the virus-vector interaction.
- By B/A-ELISA, two weed species, *Leptochloa chinensis* and *Echinochloa crus-galli*, were also found infected with RRSV (**Fig. 2.2.8**).

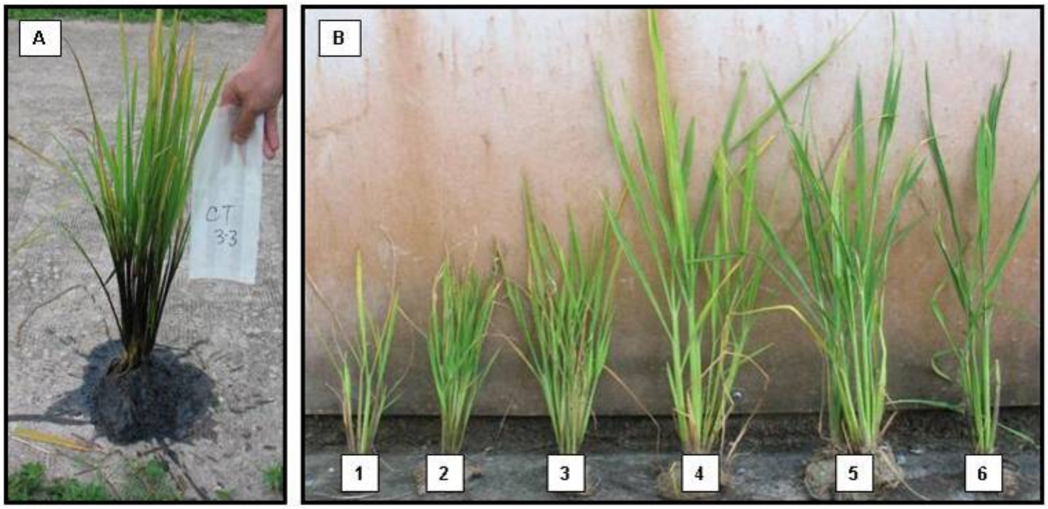


Fig. 2.2.7. Various symptoms in rice plants caused by dual infection with RGSV and RRSV. (**A**) Characteristic symptoms of yellowing syndrome showing leaf yellowing and bronzing, and profuse tillering. (**B**) Various symptoms caused by RGSV and RRSV observed in a single field in the Mekong Delta.

Fig. 2.2.8. Symptoms exhibited by two weed species infected with RRSV as detected by B/A-ELISA.

A. 2.3.1 Determine vector-virus relationships

A series of virus transmission experiments with BPH started in July of 2009 at SRPPC to characterize the relationship between rice viruses prevalent in the Mekong Delta and their insect vectors. A hands-on training course for BPH transmission of viruses and related experiments was also coincidentally offered to researchers and students working on BPH-transmitted viruses in the region (**Fig. 2.2.9**). Preliminary results on the latent period of viruses in BPH and incubation period of viruses in rice plants were obtained (**Table 2.2.1**).

Fig. 2.2.9. Training on BPH transmission of viruses and related experiments conducted in SRPPC, Vietnam, between July and September 2009.

Table 2.2.1. Latent periods in BPH and incubation periods in rice for RGSV and RRSV prevalent in the Mekong Delta region.

	Days[1] for:	
	RRSV	RGSV
Latent period in BPH (single infection)	4.53 ± 0.74	6.48 ± 1.05
Latent period in BOH (dual infection)	4.68 ± 0.75	3.72 ± 1.21
Incubation period in rice	22.54 ± 2.36	18.73 ± 2.60

[1]Average ± standard deviation.

A. 2.3.2 Determine epidemiology of spread of BPH vectors and the viruses they transmit

- During the trip of March 2009 in southern Vietnam, data on the following were collected from SRPPC and the PPD subdepartment in different provinces:
  1. Areas affected by BPH and virus outbreak in southern Vietnam from 1997 to present broken down by seasons.
  2. Areas affected by BPH and virus outbreaks in southern Vietnam from 2006 to present broken down by seasons, levels of severity, and provinces affected.
  3. BPH catches from light traps established in different provinces of southern Vietnam between 2007 and 2008.
  4. ELISA results of leaf and BPH samples collected from different provinces of southern Vietnam from 2006 to 2008.
- The data collected were analyzed to better understand the spread and distribution of BPH and virus outbreaks in southern Vietnam. Regional and seasonal differences in virus

incidences were observed based on data analyzed from 2006 to 2008 (**Fig. 2.2.10**). Monthly and daily differences in light trap catches were also observed (**Fig. 2.2.11**), which guided the implementation of the escape strategy to reduce the levels of BPH and virus outbreaks in the region.

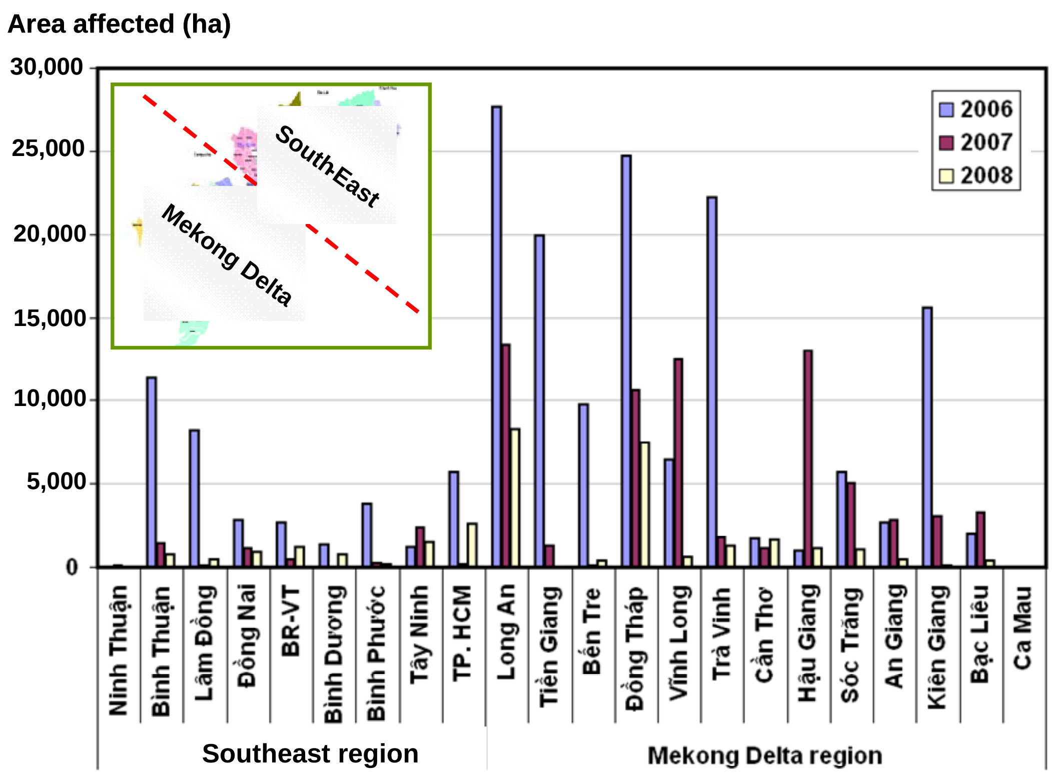


Fig. 2.2.10. Regional difference in virus incidences observed in different provinces of southern Vietnam during 2006 and 2008.

A.2.4 Screen selective cultivars for virus resistance

- Rice germplasm materials and advanced breeding lines, which were found to be resistant to/tolerant of BPH and viruses, were selected to evaluate for the reactions to RGSV and RRSV in the greenhouse by mass screening at SRPPC. The seeds of selected rice plants will be dispatched to Vietnam in 2010.

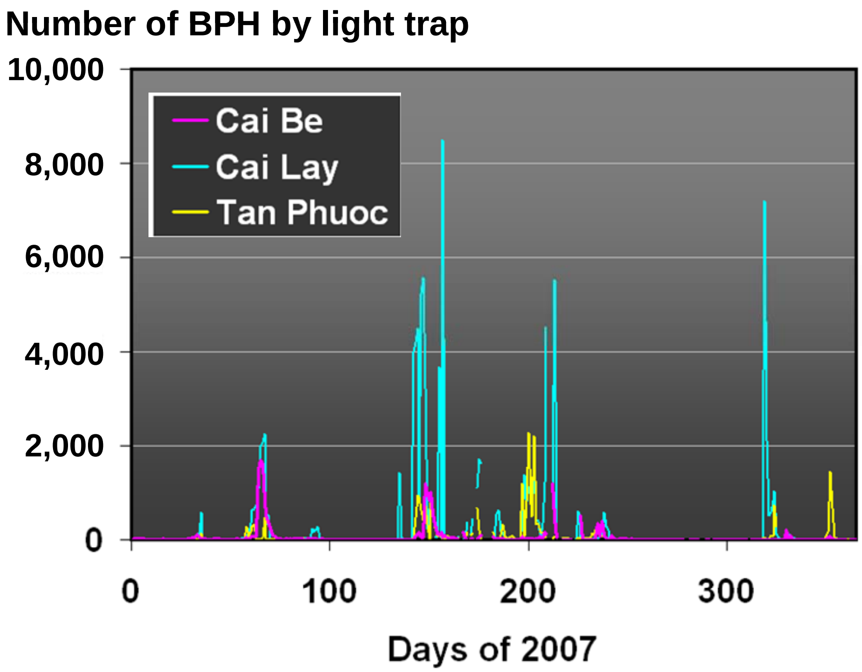


Fig 2.2.11. Daily fluctuations of BPH catches by light traps in three provinces of southern Vietnam.

Activity plan in 2010

- The following work plan for 2010 was agreed upon during the Review and Planning Workshop held in Ho Chi Minh City on 30 November-3 December 2009:

Milestones	**Work plan**	**Persons responsible**
Activity 2.1. Establish a procedure facilitating detection of RGSV and RRSV in plants and BPH from field		
2.1.2. Diagnostic procedure established	• The sensitivity of protein-based and nucleic acid-based diagnostic procedures for rice grassy stunt (RGSV) and rice ragged stunt virus (RRSV) in plants and insects will be optimized. • The reliability of diagnostic methods will be validated by a comparative examination of samples collected in fields and greenhouse.	PQ Cabauatan, RC Cabunagan, NH Huan, IR Choi
Activity 2.2. Determine biological and genetic characteristics of viruses		
2.2.3. Characteristics of viruses	• Pure cultures of RGSV and RRSV distributed in the Mekong will be isolated. • Biological characteristics of RGSV and	PQ Cabauatan, RC Cabunagan, HV Chien, PV Du,

defined	RRSV found in the Mekong such as latent period in plants, host range, and typical symptoms will be determined.	IR Choi
2.2.4. Genetic variability of viruses in Mekong defined	• Partial nucleotide sequences of RGSV and RRSV genomes found in Mekong will be determined. • The sequences of RGSV and RRSV in the Mekong will be phylogenetically analyzed by comparing those of RGSV and RRSV found in China, Thailand, Cambodia, and the Philippines.	PQ Cabauatan, RC Cabunagan, D Chettanachit, W. Rattanakarn, NV Vien, PY Yang, IR Choi
Activity 2.3. Determine vector-virus relationships and epidemiology of spread and develop management tactics		
2.3.1. Insect vectors and transmission characteristics in Mekong defined	• Transmission characteristics of RGSV and RRSV by brown planthoppers such as minimum acquisition, minimum inoculation accession, and minimum incubation periods will be determined. • Transmission characteristics will be examined for the individual viruses, and also for the conditions in which RGSV and RRSV are simultaneously transmitted.	PQ Cabauatan, RC Cabunagan, HV Chien, PV Du, IR Choi
2.3.2. Epidemic patterns of hoppers and viruses in Mekong determined	• Historical data on the incidences of RGSV, RRSV, and BPH, and BPH migration in the provinces in the Mekong will be gathered and compiled. • The compiled data will be analyzed to grasp the epidemic pattern of RGSV and RRSV in relation to BPH migration in the region.	PQ Cabauatan, RC Cabunagan, HV Chien, NH Huan, IR Choi
2.3.3. Management strategies for viruses in Mekong established	• Based on the epidemic pattern of RGSV and RRSV seen in the Mekong, and the effectiveness of escape strategies to prevent the outbreak of viruses, strategies for control of RGSV and RRSV will be conceived.	PQ Cabauatan, RC Cabunagan, HV Chien, NH Huan, IR Choi
Activity 2.4. Screen selective cultivars for virus resistance		
2.4.1. Screen method for virus resistance established	• An effective method for evaluation of reactions to RGSV and RRSV will be established based on the results of artificial inoculation of the viruses in greenhouses, and the following evaluation of virus infection in plants.	PQ Cabauatan, RC Cabunagan, HV Chien, IR Choi
2.4.2.	• Based on the previous phenotyping results	PQ Cabauatan,

Resistance sources identified	with RGSV, RRSV, and other rice viruses, promising rice germplasm stocks will be selected. • The selected germplasm stocks will be evaluated for reactions to RGSV and RRSV, respectively, in greenhouses and fields.	RC Cabunagan, HV Chien, PV Du, IR Choi
Additional activity planned for 2010		
Exchange of scientists and research knowledge among participating countries	• Scientists from Vietnam, Thailand, China, and IRRI will mutually visit research/extension organizations involved in the project to be more familiarized with the rice virus problems facing the respective countries, and to exchange research know-how and data. • Organize a workshop on emerging rice viruses such as southern rice black streak dwarf virus occurring in China and Vietnam within the first quarter of 2010.	PQ Cabauatan, RC Cabunagan, D Chettanachit, W. Rattanakarn, NV Vien, PY Yang, IR Choi

Output 3: Ecologically based management of outbreak pests, such as planthoppers, developed and key sustainability indicators of pest breakouts monitored

- Key indicators for pest monitoring have been identified and sampling procedures determined. A draft of the sampling protocol is now available online from the Ricehoppers blog (http://ricehopper.files.wordpress.com/2009/07/sampling-protocol-27-july-2009.pdf).
- A training workshop on Ecological Engineering and Research Methods for Rice Pest Management was conducted 25-29 May 2009 at Zhejiang University, Hangzhou, China. Thirty-six NARES partners trained in concepts of using the DPSIR (driving force, pressure, state, impact, response) framework in analyzing issues and developing response options, and ecological research methods to quantify the biodiversity of ecosystem service functions such as parasitization, predation, and pollination. The report is available online from the Ricehoppers blog (http://ricehopper.files.wordpress.com/2009/03/ecol-eng-workshop-training-report.pdf).
- Four ecological engineering pilot sites have been selected. Table 2.3.1 provides the details of these sites and the progress made at the time of the report.

Table 2.3.1. Details of ecological engineering pilot sites.

Site	Location	Activities and progress
1	Jin Hua, Zhejiang, China Siping Village	Jin Hua County plant protection, under the leadership of Mr. Chen Guihua, contracted a 15-ha site in Siping Village from farmers as the pilot site. They have employed one full-time

		entomologist and several support workers and built a facility with an office, lab, and accommodations to support research. The site has installed 40 light traps, planted sesame and wild flowers along all the bunds, and installed various ecological monitoring devices. The bulk of the pilot site's operating expenses, both fixed and variable costs, are borne by Jin Hua County.
2	Ling Gui, Guangxi, China	The Ling Gui site is partly supported by the Ling Gui Township plant protection center. A 30-ha site has been identified and township officials have met with farmers to develop a common understanding of the landscape modifications they will implement. The main modifications (i.e., planting of sesame and flowers) will be made on the main bunds by township officials. Farmers are encouraged to populate bunds in their fields with common beneficial flowers. Various monitoring devices, such as light traps, yellow pan traps, and sticky board traps, are being installed.
3	Cai Be, Tien Giang, Vietnam Hau My Trinh, My Thanh Nam	A 30-ha pilot site is established in Hau My Trinh Village in Cai Be District. A suite of compositae beneficial flowers will be grown along the main bunds. Planting materials have been prepared. Another site fully supported by the provincial government has also been established in Cai Lay, in My Thanh Nam Village.
4	Chainat, Thailand	The pilot site is established at the Chainat Seed and Research Station of the Rice Department. Some 30 ha have been allocated for this pilot project. The bunds will be populated with *Tridax* species and various insect traps have been set up. Two entomologists have been assigned to this activity.

Jin Hua

Sesame plants were established along the bunds of a rice field of about 0.5 hectare (Fig. 3.2.1). A neighboring farmer's field without sesame was used as a comparison. Sesame was selected because the flowers last a long time, are aromatic, and are frequently visited by hymenopteran species. In addition, the sesame seeds can be harvested for use in making candies, sesame oil, and seasoning for cooking.

Fig. 2.3.1. Sesame plants along bunds. Inset: Sesame flower with a visiting bee.

Preliminary results from the Jin Hua pilot site showed that densities of predators and parasitoids were higher in the ecological engineering field than in the farmers' practice fields (Fig. 2.3.2). Details can be found at http://ricehoppers.net/2010/02/25/rice-fields-with-sesame-grown-on-the-bunds-have-higher-natural-enemies-in-jinhua-china/.

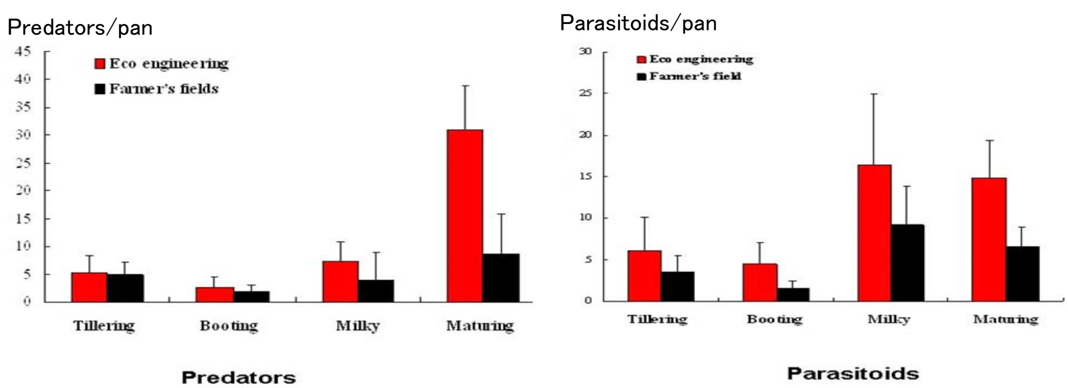


Fig. 2.3.2. Yellow pan trap catches of predators and parasitoids in ecological engineering and farmers' fields.

Cai Be

In Cai Be, farmers established several species of nectar-producing flower plants along the bunds of a total of 5 km. Yellow pan traps and sticky boards were set up to estimate predators and parasitoids in the fields. A field day was organized by the local agricultural authorities and 120 participants attended (Fig. 2.3.3).

Fig. 2.3.3. Farmers attending field day in Cai Be.

Farmers in this village apply two ecological engineering techniques, stabling nectar-producing flowers along the bunds and the "escape strategy" to avoid heavy virus infections. In addition, farmers did not apply any insecticides and planthopper populations and virus infections were low. Arthropod predator and parasitoid samples are being sorted out for data analyses.

Chainat

At the Chainat Rice Research Center, about 30 hectares were used as the pilot site. Bunds were planted with squash, pumpkin, and *Tridax* to provide resources to attract natural enemies (Figs. 2.3.4, 2.3.5).

- 

Fig. 2.3.4. Chainat Rice Research Center with bunds populated with squash, pumpkin, *Tridax*, and several other nectar-producing flora.

Fig. 2.3.5. Assessing arthropod biodiversity using a blower-vac suction sampler.

Insecticide resistance monitoring

- The standardized monitoring procedure was developed and used by all partners. A draft of these protocols is available online from the Ricehoppers blog (http://ricehopper.files.wordpress.com/2009/07/monitoring-draft-protocol.pdf).
- A training course on toxicology and insecticide resistance monitoring was conducted at IRRI, 27 April-1 May 2009, and 13 partners were trained in techniques of insect rearing, topical application, lab techniques, probit analysis, and presentation of toxicological data. A report of this training activity is available online on the Ricehoppers blog (http://ricehopper.files.wordpress.com/2009/03/workshop-report-toxicology.pdf).
- Field collections and lab rearing of sampled insects from Guilin, Zhejiang, Tien Giang, Chainat, Pila, and MUDA were used in topical application experiments at IRRI, ZAAS, Long Dinh, and Bangkhen. The probit analysis showed that BPH populations in Jin Hua, China, were highly resistant to all three active ingredients (Fig. 2.3.6). The planthopper populations at the China sites are clearly more resistant to all three active ingredients and those in the Philippines and Malaysia are the most susceptible. For fipronil, the Guilin population was found to be about 48 and 65 times more tolerant than those in the Philippines and Malaysia, respectively. For the neonicotinoid imidacloprid, populations in China were 75 to 200 times more tolerant than those in the Philippines. Populations in Thailand were 2.8 to 8.8 times more tolerant than those in the Philippines. For the compound BPMC, a carbamate, populations in the Philippines and Thailand were equally susceptible but populations in China were 10 to 45 times more resistant.

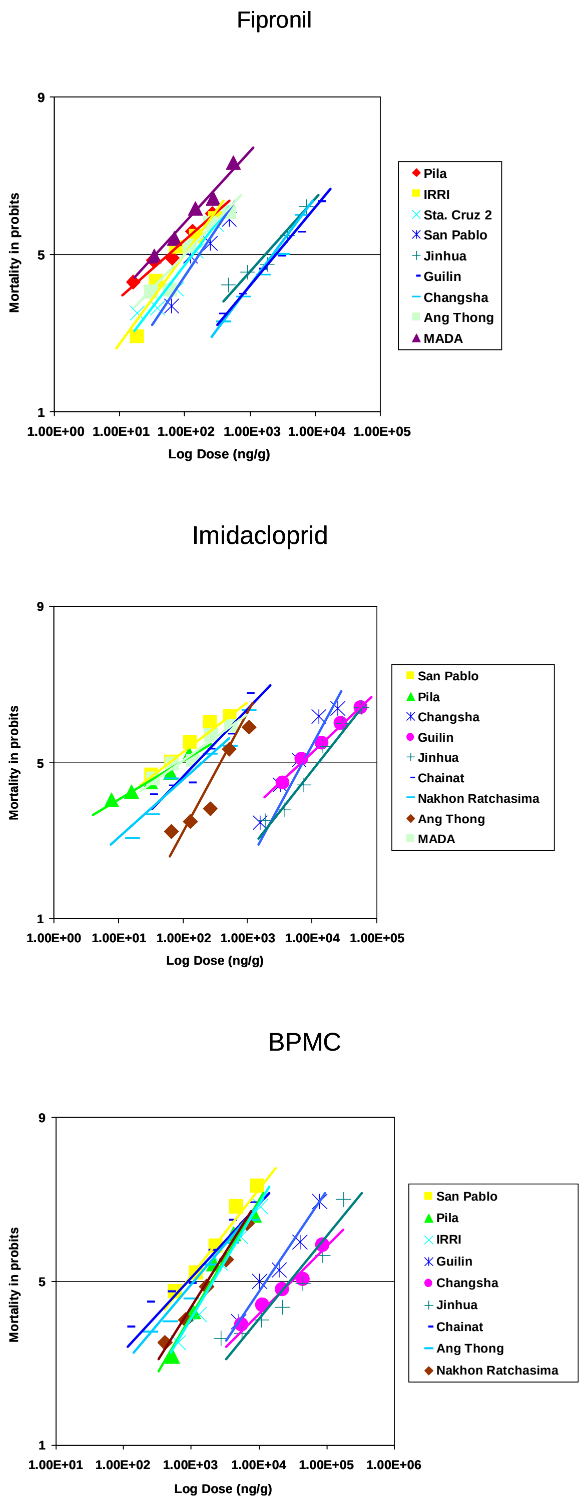


Fig. 2.3.6. The dose response lines of three insecticides to BPH populations in China, Thailand, Malaysia, and the Philippines.

2.4 Output 4: Management practices integrating durable resistance and ecological methods evaluated by farmers, communicated through policy dialogues, and up-scaled using communication media at pilot sites

- Three in-country training activities of partners in concepts of farmer decision making and sociological research methods were conducted in Bangkhen/Chainat, Thailand (30 March-3 April 2009), Long Dinh, Vietnam (20-23 April 2009), and Guilin, China (11-15 May 2009). Reports are available online (http://ricehoppers.net/project-reports/). The three in-country training workshops had to be held separately because of language differences and sociological research is highly dependent on socio-cultural and linguistic issues. A total of 116 NARES were trained (see list in Appendix 2).
- Drafts of the decision analysis tools and survey methods are available online as appendices to the workshop reports.
- Survey instruments were developed after focus group discussions were held and the instruments translated into Chinese, Thai, and Vietnamese.
- Enumerators have been trained and surveys completed in China. Vietnam and Thailand are expected to complete their surveys in August.
- Survey teams and research partners were trained on data processing and analysis to facilitate data entry and ensure quality in China (2-3 July 2009), Vietnam (20-21 July 2009), and Thailand (3-4 August 2009).
- Baseline surveys with rice farmers were conducted in China, Thailand, and Vietnam with these sample sizes: Jinhua and Lingui, China—637, Chainat, Thailand—341, and Tien Giang, Vietnam—1,009.
- From the baseline survey results, of concern are farmers' attitudes toward planthoppers, which revealed that many farmers still think that all insects in the rice field are harmful, that insecticide spraying always increases yield, that there is no other way to control planthoppers except using insecticides, and, if my neighbor sprays insecticides, I must spray too. Planting flowers on bunds provides a regulating service and cultural services such as aesthetic beauty and cultural values, an area that will appeal to women more. Likewise, planting flowers is connected to protecting human health, a primary concern of women, mothers in particular. However, farmers think that planting beneficial flowers on bunds is of no use to them, that it is a waste of time, and that it is an additional burden. However, about one-half of farmers expressed willingness to try increasing flowers on bunds and learn more about what they can do (see Table 2.3.2).

Table 2.3.2. Respondents' attitudes toward planthoppers and nonrice habitats.

Attitude statements	China		Thailand	Vietnam
	Jinhua (327)	Lingui (310)	Chainat (341)	Tien Giang (1,009)
Planthoppers				
All insects in the ricefield are harmful.	51.7%	7.4%	36.1%	21.3%
Insecticide spraying for insect control always increases yield.	94.2%	71.0%	66.7%	47.0%
There is no other way to control planthoppers except using insecticide.	76.4%	47.4%	69.5%	63.2%
If my neighbor sprays insecticides for planthoppers, I must spray too.	71.6%	31.3%	42.8%	31.4%
Nonrice habitats				
Bunds in rice fields should not have any plants on them.	31.8%	16.1%	64.2%	65.7%
All plants in the nonrice habitats are of no use to me.	52.9%	36.1%	41.0%	51.0%
Increasing beneficial flowers on bunds is an additional burden to farmers.	55.7%	22.0%	52.2%	61.4%
I am willing to try increasing beneficial flowers on bunds to learn more about what they can do.	53.3%	68.4%	47.8%	41.3%

- Focus group discussions (FGDs) with plant protection and agriculture officials in China, Thailand, and Vietnam revealed that, when faced with a pest outbreak, policymakers are governed by Simon's principle of procedural rationality. Policymakers would like to ensure absolute control or be seen doing a great deal to help farmers to ensure food security and maintain social stability. Thus, an immediate response like making emergency funds available has been the most frequent decision. Although agriculture and plant protection officials know that insecticide use is not necessary, they "do it differently" to conform to the norm and to protect their positions.

In Thailand, there seems to be agreement that BPH outbreaks are pesticide induced, but the Ministry of Agriculture has authorized the release of emergency funds for pesticide purchase of 50 million baht per province. The emergency pesticide release appears to be politically well accepted but may not be beneficial to the future of managing outbreak pests, the environment, and public health.

2.5 Output 5: NARES partners' research and extension capacities in plant resistance, ecological management of outbreak pests, insecticide resistance monitoring, and communication enhanced

- A training workshop on Ecological Engineering and Research Methods for Rice Pest Management was held at Zhejiang University, Hangzhou, China, 25-29 May 2009, with 36 participants. A report is available at http://ricehoppers.net/project-reports/.
- A training workshop on Toxicology and Insecticide Resistance Monitoring was held at IRRI, 27 April to 1 May 2009, with 14 participants. The list of participants appears in Appendix 2. The report is available at http://ricehoppers.net/project-reports/.
- Three in-country training workshops were held on Decision Making and Sociological Tools in Pest Management in China, Thailand, and Vietnam. It was necessary to hold these separately because, unlike research of a technical nature, language differences and their significance are important in sociological research. The list of participants (43) appears in Appendix 2. The completed workshops were held at
    - Kasersart University, Bangkhen and Chainat, Thailand. Report available at http://ricehoppers.net/project-reports/.
    - Long Dinh, Tien Giang, Vietnam. Report available at http://ricehoppers.net/project-reports/.
    - Guilin, Guangxi, China. Report available at http://ricehoppers.net/project-reports/.
- Three in-country training activities for interviewers and research partners on interview procedures and questionnaire pretesting and data entry were conducted and a total of 73 students from local agricultural colleges were trained.

2.6 Additional Output: Improving communication of the project

- To improve communication with partners and those interested in the issues, techniques, and discussions on rice planthopper management, a blog hosted by Wordpress was constructed and maintained. The blog, administered by Dr. M.M. Escalada of Visayas State University, started in December 2008 and by December 2009 had more than 30,000 visitors (see http://ricehoppers.net/2009/06/27/ricehoppers-blog-visitors-exceeds-10000/). The most commonly visited section of the blog was "Publications."

Chapter 3: Summary of Major Accomplishments

3.1 Output 1: New field resistance screening method and germplasm with durable field resistance to planthoppers and virus diseases identified for incorporation into new elite breeding lines and mega-varieties

- Review of resistance mechanisms completed. Chapter titled "Mechanisms of resistance: a major gap in understanding planthopper-rice interactions" submitted and to be published in September.
- Hopper colonies established at the IRRI greenhouse to select for specific gene-adapted biotypes (*bph2*, *Bph3*, *Bph9*, *Bph10,* and *Bph18*). Colonies selected on varieties Mudgo (with the *Bph1* gene) and ASD7 (with the *bph2* gene) have been maintained for screening purposes and are now entering their 50th generation.
- A physical map has been prepared for BPH and WBPH resistance genes using established molecular markers (***"Preliminary physical map of BPH and WBPH resistance genes"***).
- The extent and intensity of the 2009 Santa Cruz outbreak was monitored and interviews conducted with affected farmers to determine possible causes of the outbreak (**see *"Planthopper outbreak on a hybrid rice farm in Sta. Cruz, Laguna, Luzon, Philippines"* by L.M. Almazan, C.C. Bernal, and F.G. Horgan,** http://ricehoppers.net/from-m-l-almazan-c-bernal-f-horgan/).
- Experiments were completed to examine possible heterosis in hybrid rice for resistance to/tolerance of BPH and WBPH. Data are currently being analyzed.
- New hybrid experiments were set up using 32 varieties for physiological characteristics and insect resistance correlations.
- Experimental designs for testing of field and greenhouse screening methods have been prepared in collaboration with NARES partners and differential lines increased.
- Initial screening trials and evaluations were conducted at IRRI and test protocols evaluated. Virulence of Laguna-Philippines populations was examined.
- Reactions of GLH to NILs and PYLs from Kyushu University have been evaluated. The effects of pyramiding genes on durability will be assessed using newly established hopper populations.
- A questionnaire was developed based on a series of focus group discussions held at Iloilo (**for further details, see *"Will farmers rely on varietal resistance to combat insect attack?"* By F.G. Horgan, C. Arroyo, M.M. Escalada, and K.L. Heong, http://ricehoppers.net/2009/06/25/will-farmers-rely-on-varietal-resistance-to-combat-insect-attack/**).

3.2 Output 2: Strategies to manage virus spread in rice fields developed and implemented at pilot sites.

- Improvement in identification of plants infected with RGSV and RRSV in leaf and BPH samples by enzyme-linked immunosorbent assays (ELISA).
- Determination of optimal sampling and storage conditions of leaf and BPH samples collected from fields for better estimation of virus prevalence.
- Determination of BPH-transmitted virus species (RGSV and RRSV) and plant species (rice and weeds) affected by BPH-transmitted viruses in southern Vietnam.
- Improvement of the sensitivity of ELISA for RRSV by introducing the avidin-biotin system.
- Evaluation for the transmission characteristics of RGSV and RRSV by BPH prevalent in southern Vietnam.
- Conducting training sessions for virus detection by ELISA and RT-PCR, and for insect transmission of viruses in southern Vietnam and IRRI.
- Collecting and compiling of historical data for incidences of BPH and associated viruses in southern Vietnam to be used for epidemiological analysis.

3.3 Output 3: Ecologically based management of outbreak pests, such as planthoppers, developed and key sustainability indicators of pest breakouts monitored.

- Four ecological pilot sites established in China, Vietnam, and Thailand. At these sites, the land areas surrounding rice fields have been modified and populated with plants that are beneficial to natural enemies and various monitoring devices are installed for data gathering over the season.
- Standard ecological research procedures are in place.
- The Insecticide Resistance Monitoring Network involving project countries, China, Vietnam, and Thailand, plus Malaysia and Japan, supported by their own funds, was established. Standardized protocols and analyses were developed and partners trained.

3.4 Output 4: Management practices integrating durable resistance and ecological methods evaluated by farmers, communicated through policy dialogues, and up-scaled using communication media at pilot sites.

- Some 116 research partners were trained in concepts of decision making, sociological methods, and conducting farm surveys.
- Baseline sociological survey instruments were finalized, pretested, and translated into Chinese, Vietnamese, and Thai and surveys initiated at Guilin and Jin Hua (China), Cai Be and Cai Lay (Vietnam), and Chainat (Thailand).
- An extensive data set on 1,987 rice farmers' insecticide use patterns and attitudes toward planthopper management and ecological engineering is available.

3.5 Output 5: NARES partners' research and extension capacities in plant resistance, ecological management of outbreak pests, insecticide resistance monitoring, and communication enhanced

- Five training workshops were held. A total of 92 NARES partners were trained in ecological research, toxicology, sociology, and survey methods.
- Seventy-three college students from China, Vietnam, and Thailand were trained as enumerators.
- On-the-job training of PhD students from Khon Kaen University (Ms. Supaporn Chagarun and Ms. Rujirat Wongchandaeng) for 2 months on biodiversity analysis was completed.

3.6 Additional Outputs: Improving communication

- The Rice Planthopper blog was established and actively maintained. The number of visitors gradually increased from about 1,000 in January to about 30,000 in December (Fig. 2.6.1).

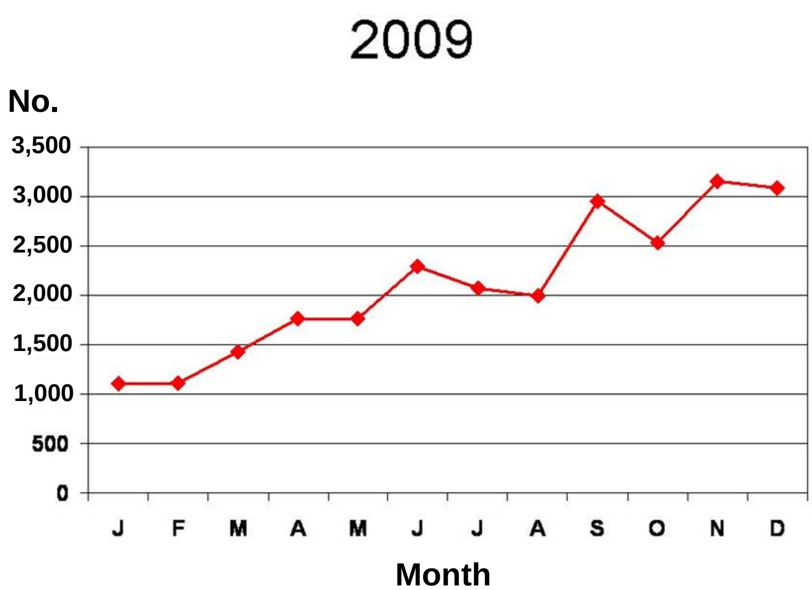


Fig. 2.6.1. Monthly total of visitors to Ricehoppers blog in 2009.

- Book on planthoppers published.
- Proposals for national support for planthopper research prepared and supported. Leveraged a total of $6.4 million to support research in China and Thailand.
    - China. Ministry of Science and Technology (MOST), $4.4 million for 5 years.
    - China. Natural Science Foundation (NSF) for China-IRRI collaboration to understand differences in population characteristics between temperate and tropical rice planthoppers. $150,000 for 3 years.

- Thailand. A 58 million baht grant (approx. $1.8 million) from the Ministry of Agriculture for 3 years to develop sustainable strategies to manage planthopper outbreaks.
- Thailand. A 1 million baht grant (approx. $30,000) to expand ecological engineering at 10 sites in Uthai Tani Province.

Chapter 4: Issues Realized and Solutions

In the course of conducting capacity building of NARES, it became apparent that many younger NARES scientists lack basic training in ecology, toxicology, sociology, and communication sciences. The training courses we have completed merely addressed the fundamental concepts but did not address the advanced and analytical issues. To enhance NARES capacity, we now need to adopt a continuous peer-mentoring approach rather than just training. Further capacity-building activities in the next 12 months will examine the more advanced issues, data analysis, and interpretations once partners have their collected data. In these training workshops, partners' capacities in advanced topics, data analysis methods, and data analysis will be addressed.

Chapter 5: Conclusions

Project activities planned for the first 6 months were carried out as planned. The focus of the first year is to increase NARES capacity, develop research and screening techniques (to obtain baselines), review literature, and build NARES teams. After 6 months, a large part of these tasks have been achieved. The project will focus on NARES setting up various experiments and data gathering, data analyses, and interpretation. At IRRI, research to identify the mechanisms of insect-/host-plant relationships, studies to understand insect-virus-plant relationships, quantifying the fitness of WBPH on hybrid rice varieties, further refinement of the resistance characters for breeding, understanding mechanisms of insecticide mixtures, and understanding decision-making constraints among plant protection policy decision makers will continue.

Ecological engineering concepts are beginning to be adopted with all three research partners, China, Thailand, and Vietnam. The associate partner, Malaysia, has started a new project on developing ecological engineering methods (approx. $100,000).

Appendix 1

13th RETA PERFORMANCE REPORT
AS of September, 2009

A. PROJECT MAIN FEATURES

RETA NO: TA6489	Bringing about a sustainable agronomic revolution in rice production in Asia by reducing preventable pre- and postharvest losses
IMPLEMENTATION AGENCY:	International Rice Research Institute (IRRI)
PARTICIPATING COUNTRIES:	Cambodia, China, Philippines, Thailand, Vietnam
MAIN OBJECTIVES:	Subcomponent 1 aims to reduce crops' vulnerability to preharvest losses caused by planthopper outbreaks. These outbreaks result from low invasion resistance in the cropping system. Susceptible varieties may contain no planthopper resistance genes at all or just one or two "seed box" genes that break down easily. Such ecosystem services as natural biological control keep planthoppers in low densities, and when these services are compromised by climate change or excessive insecticide use, planthopper and virus outbreaks occur. This Subcomponent's activities will focus on developing a new phenotypic assessment technique to identify field-resistance genes, virus epidemiology, and population ecology to integrate field resistance using ecological engineering principles and develop sustainable management methods for preventing outbreaks that can be communicated via extension channels and media to thousands of rice farmers.

APPROVAL DATE	TA AGREEMENT SIGNING DATE	COMMENCEMENT DATE	ELAPSED TA PERIOD:	CLOSING DATE		
	6 November 2008					

B. STATUS OF TA FUND UTILIZATION

TOTAL GRANT:	CUMULATIVE DISBURSEMENT	CUMULATIVE EXPENDITURE	OUTSTANDING ADVANCE:
2,000,000$	$975,000	960,372	$14,628

C. IMPLEMENTATION PROGRESS

DATE OF LAST REVIEW MISSION	
DATE OF LAST SEMIANNUAL PROGRESS REPORT	20 August 2009
OVERALL IMPLEMENTATION PROGRESS BASED ON LATEST REVIEW MISSION AND/OR PROGRESS REPORT: {ADB input]	

COMPLIANCE WITH MAJOR COVENANT

DESCRIPTION	STATUS OF COMPLIANCE
1. Submission of Inception Report	Submitted
2. Submission of semiannual progress report	Submitted
3. Submission of semiannual financial report	Submitted
4. Submission of audited annual financial report	Submitted
5. Submission of comprehensive completion report	

Appendix 2: List of participants in capacity building training/workshops and topics they were trained in.

List of persons from NARES trained

Training workshop: Ecological Engineering and Research Methods for Rice Pest Management
Total trained: 36

Name	Institution	Country
Mr. Yi-ling Xie	Guangxi Provincial Station of Plant Protection	China
Mr. Cheng-sheng Xu	Lingui County Station of Plant Protection	China
Mr. Wen-xing Wu	Lingui County Station of Plant Protection	China
Mr. Hui Yang	Cha Dong Township Station of Agricultural Technology and Extension	China
Mr. Jian-bo Lu	Cha Dong Township Station of Agricultural Technology and Extension	China
Ms. Xian-xin Li	Cha Dong Township Station of Agricultural Technology and Extension	China
Ms. Rong Guo	National Agricultural Technology Extension and Service Center, Beijing	China
Mr. Xu-song Zheng	Zhejiang Academy of Agricultural Sciences, Hangzhou	China
Mr. Gui-hua Chen	Jin Hua Plant Protection Station, Zhejiang	China
Mr. Xian-qiao Sun	Jin Hua Plant Protection Station, Zhejiang	China
Mr. Jiang-xing Wu	Ningbo Plant Protection Station, Zhejiang	China
Mr. Zhao-pu Peng	Hunan Academy of Agricultural Sciences, Zhejiang	China
Dr. Hua-feng Lin	Anhui Agricultural University, Anhui	China
Mr. Xuehui Jiang	Zhejiang Plant Protection and Quarantine Bureau	China
Mr. Jin-liang Zhu	Jiaxing Plant Protection Station	China
Mr. Wei-xin Shen	Huzhou Academy of Agricultural Sciences, Zhejiang	China
Mr. Ming-long Fu	Cannan Plant Protection Station, Zhejiang	China
Mr. Yong-min Zheng	Liushi Town Agricultural Tech Station, Yueqing, Zhejiang	China
Mr. Gen-xin Zhu	Jindong Plant Protection Station, Jin Hua, Zhejiang	China
Mr. Hong-hai Zheng	Xiangshan Agricultural Bureau, Zhejiang	China
Mr. Jian-ren Ye	Wenlin Plant Protection Station, Zhejiang	China

Ms. Lin Zhong	Jiangxi Provincial Plant Protection Bureau, Jiangxi	China
Dr. Qiang Li	Yunnan Agricultural University, Yunnan	China
Mr. Guang-hua Wang	Institute of Insect Sciences, Zhejiang University	China
Mr. Wen-wu Zhou	Institute of Insect Sciences, Zhejiang University	China
Ms. Qiong Yang	Institute of Insect Sciences, Zhejiang University	China
Ms. Xue-qin Wang	Institute of Insect Sciences, Zhejiang University	China
Dr. Mohd Norowi Hamid	Strategic Resource Research Division, MARDI	Malaysia
Mr. Manit Luecha	Rice Seed Center	Thailand
Mr. Somsak Thongdeethae	Chainat Rice Research Center	Thailand
Ms. Nalinee Chiengwattana	Chainat Rice Research Center	Thailand
Mr. Chairat Channoo	Chainat Rice Research Center	Thailand
Mr. Ho Van Chien	Southern Plant Protection Center, Long Dinh, Tien Giang	Vietnam
Mr. Nguyen Van Khang	Department of Agriculture of Tien Giang, My Tho City, Tien Giang	Vietnam
Mr. La Pham Lan	Institute for Agricultural Sciences, Ho Chi Minh City	Vietnam
Dr. Nguyen Van Huynh	Can Tho University, Can Tho Province	Vietnam

Training workshop: Toxicology and Insecticide Resistance Monitoring
Total trained: 13

Name	Institution	Country
Yan Ling	Institute of Plant Protection, Guangxi Academy of Agricultural Sciences, Nanning	China
Yalin Bian	College of Life Sciences, China	China
Guihua Chen	Plant Protection Station, Jin Hua, Zhejiang	China
Facheng Zhang	Plant Protection Station, Jin Hua, Zhejiang	China
Wantana Sriratanasak	Bureau of Rice Research and Development, Bangkhen	Thailand

Sukanya Tepundung	Bureau of Rice Research and Development, Bangkhen	Thailand
Chairat Channu	Chainat Rice Research Center, Bureau of Rice Research and Development	Thailand
Pham Van Tuong	Pesticides Control Center for South Vietnam, PPD, Ho Chi Minh City	Vietnam
Nguyen Pham Hung	Pesticides Control Center for North Vietnam, PPD, Hanoi	Vietnam
Le Van Thiet	Southern Regional Plant Protection Center, PPD, Ho Chi Minh City	Vietnam
Maisarah Mohamad Saad	MARDI Alor Setar	Malaysia
Abdul Aziz Atta Mohammad	MARDI Serdang	Malaysia
Carlos Garcia	Forest Products, College, Laguna	Philippines

Training workshop: Decision Making, Sociological Tools, and Impact Assessment in Pest Management

Total trained: 43

1.1 Bangkhen & Chainat, Thailand, 30 March-3 April 2009

Name	Institution	Country
1. Ms. Wantana Sriratanasak	BRRD, Rice Department, Bangkhen	Thailand
2. Mr. Wichit Sirisantana	BRRD, Rice Department, Bangkhen	Thailand
3. Ms. Nuchaya Na Songkhla	BRPE, Rice Department, Bangkhen	Thailand
4. Mr. Somkid Popan	BRPE, Rice Department, Bangkhen	Thailand
5. Mr. Manit Luecha	Chainat Rice Seed Center	Thailand
6. Mr. Somsak Thongdeethae	Chainat Rice Research Center	Thailand
7. Ms. Nalinee Chiengwattana	Chainat Rice Research Center	Thailand
8. Ms. Narisara Juroonwong	Chainat Rice Research Center	Thailand
9. Mr. Chairat Channoo	Chainat Rice Research Center	Thailand
10. Ms. Wannaphan Janlapa	Prachinburi Rice Research Center	Thailand
11. Ms. Somrote Prakobbun	Prachinburi Rice Research Center	Thailand

1.2 Long Dinh, Tien Giang, Vietnam, 20-23 April 2009

Name	Institution	Country
1. Nguyen Van Hai	Cai Be District, Plant Protection Sub-Department, Tien Giang	Vietnam
2. Phan Ba Hung	Plant Protection Station, Cai Be District, Tien Giang	Vietnam
3. Nguyen P. Thanh Dung	Plant Protection Station, Cai Be District, Tien Giang Province	Vietnam
4. Vo Thanh Hung	Plant Protection Station, Cai Be District, Tien Giang	Vietnam
5. Pham Van Hai	Plant Protection Station, Cai Lay District, Plant Protection Sub-Department, Tien Giang	Vietnam
6. Le Van Sy	Plant Protection Station, Cai Lay District; Plant Protection Sub-Department, Tien Giang Province	Vietnam
7. Nguyen Van Chat	Plant Protection Station, Cai Lay District; Plant Protection Sub-Department, Tien Giang	Vietnam
8. Nguyen Thanh Bieu	Division of Technique, Plant Protection Sub-Department, Tien Giang	Vietnam
9. Pham Van Tam	Division of Technique, Plant Protection Sub-Department, Tien Giang	Vietnam
10. Ho Chi Dung	Agricultural Variety Station in Cai Be District, Department of Agriculture and Rural Development	Vietnam
11. Nguyen Thi Thuy Dung	Southern Regional Plant Protection Center, Long Dinh, Tien Giang	Vietnam
12. Ly Hung	Southern Regional Plant Protection Center, Long Dinh, Tien Giang	Vietnam
13. Le Van Thiet	Southern Regional Plant Protection Center, Long Dinh, Tien Giang Province	Vietnam
14. Pham Minh Sang	Pesticides Control Center, South Vietnam, PPD, Ho Chi Minh City	Vietnam

1.3 Guilin, Guangxi, China, 20-23 April 2009

Name	Institution	Country
1. Guo Rong	Senior Agronomist, Division of Pest Control, NATESC, MOA	China
2. Xiong Yankun	Agronomist, Division of Pest Control, NATESC, MOA	China
3. Wang Kaixue	Director, Guangxi Plant Protection Station	China
4. Wang Huasheng	Extension Researcher, Guangxi Plant Protection Station	China
5. Deng Kangkang	Director, Guilin Agriculture Bureau	China
6. Chen Jingqiang	Director, Lingui Agriculture Bureau	China
7. Li Guogang	Senior Agronomist, Guilin Plant Protection Station	China
8. Xu Chengsheng	Agronomist, Lingui Plant Protection Station, Guangxi	China
9. Zhou Zhenlin	Agronomist, Lingui Plant Protection Station, Guangxi	China
10. Wu Wenxing	Agronomist, Lingui Plant Protection Station, Guangxi	China
11. Yang Hui	Agronomist, Agro-Technical Extension Station of Chadong Township, Lingui County, Guangxi	China
12. Lu Jianbo	Agronomist, Agro-Technical Extension Station of Chatong Township, Lingui County, Guangxi	China
13. Li Xianxin	Agronomist, Agro-Technical Extension Station of Chadong Township, Lingui County, Guangxi	China
14. Qin Baorong	Senior Agronomist, Guangxi Plant Protection Station	China
15. Lili	Senior Agronomist, Guangxi Plant Protection Station	China
16. Xie Yiling	Agronomist, Guangxi Plant Protection Station	China
17. He Meixian	Associate Professor, Jinhua College, Zhejiang	China

18. Huang Xue-Ping	Associate Professor, Jinhua College, Zhejiang	China

Training on survey procedures, questionnaire pretesting, and data entry

Total trained: 73

1.1 Jinhua, Zhejiang, China, 2-3 July 2009

Name	Institution	Country
1. Jia Fang-Zhao	Guilin City Station of Plant Protection, Guangxi	China
2. Xu Cheng-Sheng	Lingui County Plant Protection Station, Lingui, Guangxi	China
3. Lu Jian-Bo	Chadong Township, Lingui County, Lingui, Guangxi	China
4. Huang Xue-Ping	Associate Professor, Jinhua College	China
5. He Mei-Xian	Associate Professor, Jin Hua College	China
6. Luo Jun	Assistant Professor, Jin Hua College	China
7. Chen Gui-Hua	Plant Protection Station, Jin Hua, Zhejiang	China
8. Zhu Zeng-Rong	State Key Laboratory of Rice Biology; Institute of Insect Sciences, Zhejiang University, Hangzhou	China
9. Ruan Guo-Dong	Jin Hua College	China
10. Ning Li-Feng	Jin Hua College	China
11. Chen Qing-Hua	Jin Hua College	China
12. Xu Hui	Jin Hua College	China
13. Lei Jing-Yin	Jin Hua College	China
14. Yao Bei	Jin Hua College	China
15. Xu Chao-Lin	Jin Hua College	China
16. Ma Ting	Jin Hua College	China
17. Du Ying-Hong	Jin Hua College	China
18. Ke Hai-Xia	Jin Hua College	China
19. XingJun-Yue	Jin Hua College	China
20. Chen Bei - Bei	Jin Hua College	China
21. Zhou Li	Jin Hua College	China

1.2 Long Dinh, Tien Giang, Vietnam, 20-21 July 2009

Name	Institution	Country
1. Le Van Thiet	Southern Regional Plant Protection Center	Vietnam
2. Pham Minh Sang	Pesticides Control Center, HCMC	Vietnam
3. Nguyen Van Hai	Plant Protection Station, Cai Be District	Vietnam
4. Vo Thanh Hung	Plant Protection Station, Cai Be District	Vietnam
5. Phan Ba Hung	Plant Protection Station, Cai Be District	Vietnam
6. Pham Van Thai	Plant Protection Station, Cai Lay District	Vietnam
7. Le Van Sy	Plant Protection Station, Cai Lay District	Vietnam
8. Pham Van Thai	Plant Protection Station, Cai Lay District	Vietnam
9. Nguyen Thi Thuy Dung	Southern Regional Plant Protection Center	Vietnam
10. Ly Hung	Southern Regional Plant Protection Center	Vietnam
11. Le Phuoc Thuan	University of Forest and Agriculture	Vietnam
12. Vo Thanh Luan	University of Forest and Agriculture	Vietnam
13. Vo Quoc Phong	University of Forest and Agriculture	Vietnam
14. Nguyen Tri Dung	University of Forest and Agriculture	Vietnam
15. Le Thi Thuy Tien	University of Forest and Agriculture	Vietnam
16. Ngo Hoan Toan	University of Forest and Agriculture	Vietnam
17. Hoang Thi Quynh	University of Forest and Agriculture	Vietnam
18. Tran Hong Quyen	University of Forest and Agriculture	Vietnam
19. Nguyen Minh Vuong	University of Forest and Agriculture	Vietnam
20. Nguyen Minh Duy Anh	University of Forest and Agriculture	Vietnam

21. Le Van Dua	University of Forest and Agriculture	Vietnam
22. Huynh Thi Cam Hong	University of Forest and Agriculture	Vietnam

1.3 Chainat, Thailand, 3-4 August 2009

Name	Institution	Country
1. Somchai Thatakian	Vice-Director, Chainat Agricultural and Technology College	Thailand
2. Kamonlak Puangsombat	Lecturer, Chainat Agricultural and Technology College	Thailand
3. .Pantipa Sonmuang	Lecturer, Chainat Agricultural and Technology College	Thailand
4. Jaran Sundech	Chainat Agricultural and Technology College	Thailand
5. Pungpaka Phongphanchareen	Chainat Agricultural and Technology College	Thailand
6. Satit Kun Ket	Chainat Agricultural and Technology College	Thailand
7. Pawita Thukook	Chainat Agricultural and Technology College	Thailand
8. Thasanee Takunpasphaspacarta	Chainat Agricultural and Technology College	Thailand
9. Chutima Kankaow	Chainat Agricultural and Technology College	Thailand
10. Amnat Seilothok	Chainat Agricultural and Technology College	Thailand
11. Pornchanok Rattanajaruen	Chainat Agricultural and Technology College	Thailand
12. Chanawong Taweepanpan	Chainat Agricultural and Technology College	Thailand
13. Uttapoom Raksucksakan	Chainat Agricultural and Technology College	Thailand
14. Winit Lapphormsusol	Chainat Agricultural and Technology College	Thailand
15. Noppadon Chirada	Chainat Agricultural and Technology College	Thailand
16. Anong Promrangsaa	Chainat Agricultural and Technology College	Thailand
17. Suchin Onkam	Chainat Agricultural and	Thailand

	Technology College	
18. Varavut Phairotamonchai	Sukhothai University	Thailand
19. Dr. Wantana Sairattanasak	Bureau of Rice Research and Development	Thailand
20. Jintana Chaiwong	Bureau of Rice Research and Development	Thailand
21. Wichit Sirisantana	Bureau of Rice Research and Development	Thailand
22. Somrote Prakopboon	Prachinburi Rice Research Center	Thailand
23. Wannaphan Janlupha	Prachinburi Rice Research Center	Thailand
24. Narisara Jumroonwong	Chainat Rice Research Center	Thailand
25. Nalinee Chaingwattana	Chainat Rice Research Center	Thailand
26. Chairat Channoo	Chainat Rice Research Center	Thailand
27. Manit Luecha	Chainat Rice Seed Center	Thailand
28. Sawat Hanprab	Chainat Rice Seed Center	Thailand
29. Suvit Peagjean	Chainat Rice Seed Center	Thailand
30. Wongduan Worrapat	Chainat Rice Seed Center	Thailand

Output 4 - Total trained: 116 (as of 12 August 2009)