JARQ 48 (2), 167 - 173 (2014) http://www.jircas.affrc.go.jp

Current Status of the Occurrence and Farmer Perceptions of Rice Planthopper in Cambodia

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Abstract

This study aims to clarify the current status of rice plant damage caused by the brown planthopper (BPH) in Cambodia through semi-structured interviews with government officials and rice farmers from the main rice-producing province. BPH is known to cause serious damage to rice crops in many Southeast Asian countries. However, few studies exist on the damage caused by BPH in Cambodia and information on effective pest-control management remains limited. Interviews with provincial government officials revealed that BPH infestation had been recorded in 6 of 8 target provinces located near the border with the southern part of Vietnam. Of these, Takeo province was selected for a more detailed survey using semi-structured interviews with district government officials and workshop-style interviews with 416 farmers from 3 communes. These interviews indicated that damage by BPH in Cambodia was possibly attributable to BPH occurrence in the Mekong Delta of Vietnam.

Discipline: Insect pest
Additional key words: brown planthopper, Mekong Delta, workshop-style interview

Introduction

Rice is a staple crop cultivated across a wide expanse of Southeast Asia. Cambodia represents one of the countries in this region, with 65.0% of the total population working in agriculture; consequently, the livelihood of most farmers primarily depends on rice cultivation[7]. However, Cambodia only produces 2.9 t/ha of rice, which is a remarkably low level compared to neighboring Vietnam, which produces an average 5.3 t/ha of rice[7].

One of the important factors explaining these low rice yields in Cambodia is damage by pest insects and disease. The brown planthopper (BPH) *Nilaparvata lugens* Stål, one of the rice planthopper species, is distributed widely in East and Southeast Asia[4,6] and has become a serious pest after the "green revolution"[3]. BPH suck sap from the phloem of growing rice plants, thus impairing plant development[10]. When BPH population densities increase, the rice plants completely wilt and dry, causing prominent circular patterns in the rice field, which are termed as "hopperburn"[6,10]. In addition, BPH transmits viruses, such as rice grassy stunt and rice ragged stunt, which depress rice growth and cause low yields[9,10]. In the Mekong Delta of Vietnam, heavy devastation by BPH and diseases attributable to BPH-transmitted viruses were recorded in 2006 and 2007[1,2,5,8]. Consequently, Vietnam established a pest-control program by shifting the sowing time to a period when high BPH population density was not expected. Since 2010, the occurrence of BPH has tended to be low in the area (personal communication with Dr. Ho).

On the basis of the records from Vietnam, we conjectured that low rice yields in Cambodia were attributable to BPH and BPH-transmitted viruses. In 2007, BPH-transmitted viruses were detected near the Vietnam border of Cambodia[2,8]; however, we found limited studies relating to past damage attributable to BPH or its current distribution status in Cambodia. As a preliminary survey, we conducted interviews with the central government officials and collected rice planthopper samples from a rice field in Takeo province in September 2011. We interviewed central government officials, including the acting director of the Department of Plant Protection Sanitary and Phyto-sanitary in the General Directorate of Agriculture (GDA) and the director of the Department of Plant Protection in Cambodian Agricultural Research Development Institute (CARDI), to clarify the status of rice pests, extent of damage, and availability of previous studies in Cambodia. According to these

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Received 21 March 2013; accepted 2 September 2013.

officials, the occurrence of BPH and resultant damage has recently become a major problem. Additional field surveys were conducted, in which rice planthoppers were collected using light traps, with BPH being the main rice planthopper species collected. These observations indicate that BPH is a credible pest in Cambodia, as well as in the Mekong Delta of Vietnam. It is important to understand the occurrence of BPH in Cambodia to design an effective control system against this pest in the southern part of the Indochina peninsula. This study aims to determine the extent of BPH-damage in Cambodia through semi-structured interviews with government officials and workshop-style interviews with rice farmers.

Materials and Methods

1. Semi-structured interviews with Provincial Department of Agriculture officials

We selected 8 of 24 provinces in Cambodia as study areas to determine the extent of BPH-damage. These 8 provinces are generally recognized as being main rice-producing areas[12], and as such, are representative of the current situation across the entire rice-producing area of Cambodia. Semi-structured interviews are a qualitative method in which the interview is followed by a pre-determined questionnaire and interviewees are allowed to respond freely. This type of interview was conducted with the directors or vice directors at the Provincial Department of Agriculture (PDA) offices in December 2011. The interviews were focused on the levels of BPH infestation within their provinces. We then selected 1 province (Takeo) that had been subject to BPH-damage, to conduct a further detailed survey.

2. Semi-structured interviews with District Agricultural Office officials in the damaged area

Semi-structured interviews with the chief or vice chief at the district agricultural offices (DAO) of the selected province were conducted in January 2012 using a questionnaire form to determine the extent of BPH-damage within their districts. We then selected 3 of 10 districts to conduct interviews with farmers.

3. Workshop-style interviews with rice farmers in the damaged area

(1) Data collection

Workshop-style interviews are a type of participatory rural appraisal, and were conducted in the study area to determine the extent to which the farmers were able to recognize BPH-damage. For the purposes of this study, a commune was chosen from each selected district, with communes from different locations selected to analyze the differences among locations. For instance, R-commune was located in the middle of Takeo province, while CT- and PR-communes were located in northern and southern areas, respectively. The rice farmers from all 38 villages in the 3 communes participated in workshop-style interviews during February 2012. We requested through the village chief that 10–15 rice farmers participate in the workshop conducted in each village. The participants were asked questions related to their rice farming techniques and BPH-damage. To collect accurate data and avoid misunderstanding as far as possible, most questions were visual; tables, pictures, letters, and figures were used, with farmers answering questions by placing colored paper onto large-sized posters.

The participants were asked what rice varieties they had cultivated from 2006 to 2011, along with their annual rice-planting plan. Rice varieties in Cambodia are generally categorized into 3 types based on the growing duration: late (L), medium (M), and early (E) maturing varieties[16]. A number of questions were asked about this issue, because the farmers used wide-ranging rice varieties.

Photographs of BPH specimens and hopperburn attributable to BPH were shown to the farmers, and they were questioned about the rice varieties (late, medium, and early-maturing varieties) damaged from 2006 to 2011. Furthermore, data were requested regarding BPH-damage at different rice-growth stages and the extent of damage. The rice-growth stage was categorized into 3 groups: (1) from sowing to transplanting (BT), (2) from transplanting to flowering (BF), and (3) from flowering to harvesting (BH). The extent of damage was classified into 2 groups based on the percentage of damaged area, because the subjective interpretation of damage differed among farmers depending on the size of their fields: (1) A-damage: when hopperburn covered more than half the area of their rice field and (2) B-damage: when hopperburn covered less than half the area of their rice field.

(2) Data analysis

Logistic regression analysis was used to determine the association significance. The objective variable was whether they observed BPH-damage (Yes = 1, No = 0) for each extent of damage (A-/B-damage). The independent variables were (1) commune location (R, CT, and PR), (2) year (from 2006 to 2011), (3) rice variety (late-, medium-, and early-maturing varieties), and (4) rice growth stage (pre-transplanting, pre-flowering, and pre-harvesting). Excel statistical analysis add-in software (Excel statistic 2012; Social Survey Research Information Co., Ltd., Tokyo, Japan) was used to analyze the data. The statistical significance (denoted using an asterisk) was set at $P < 0.05$.

Results

1. Status of BPH-damage as determined from semi-structured interviews with PDA officials in high-yield areas

Fig. 1 shows the damage attributable to BPH in the 8 target provinces, with damage expressed as all or none. In 2007, BPH-damage was identified in 6 provinces located near the Vietnam border. After 2008, damage continued to occur in Takeo (TK), Svay Rieng (SR), and Prey Veng (PV) provinces. In contrast, damage was not recorded in 2 other provinces located near Thailand for 6 successive years (Fig. 1). Among the 8 provinces, Takeo province was selected as the target for the in-depth survey.

2. Status of BPH-damage determined from semi-structured interviews with DAO officials in Takeo province

The extent of damage attributable to BPH in all 10 districts of Takeo province is shown in Fig. 2, with damage expressed as all or none. In 2007, BPH-damage was identified in all districts. After 2008, the damage seemed to occur in only a few districts located close to Vietnam.

3. Recognition of rice planthoppers by farmers in Takeo province from workshop-style interviews

Workshop-style interviews were conducted in 3 communes, with 416 valid responses (R: 110; CT: 179; PR: 127

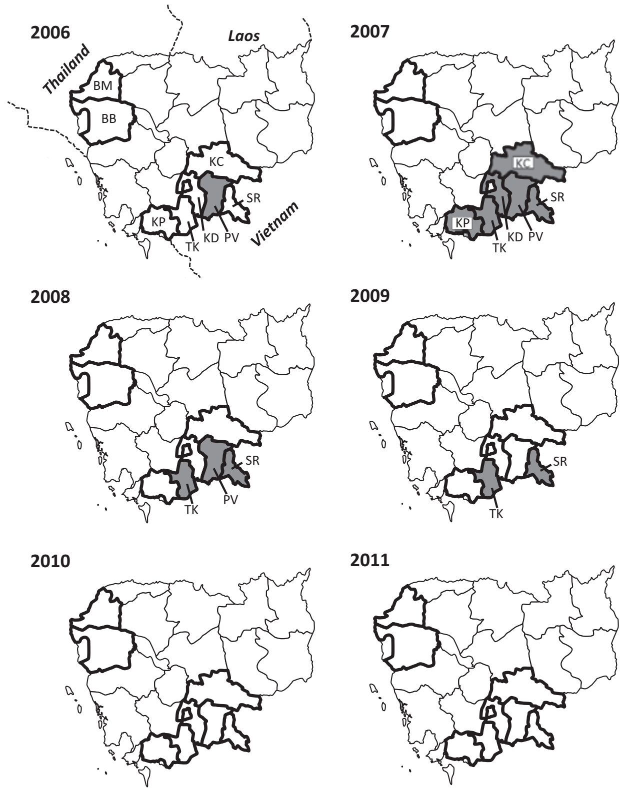

Fig. 1. Brown planthopper (BPH) damage in the main rice-producing provinces of Cambodia from 2006 to 2011
Provinces: KP, Kampot; TK, Takeo; KD, Kandal; PV, Prey Veng; SR, Svay Rieng; KC, Kampong Cham; BM, Banteay Meanchey; BB, Battambang; gray-color: provinces damaged by BPH.

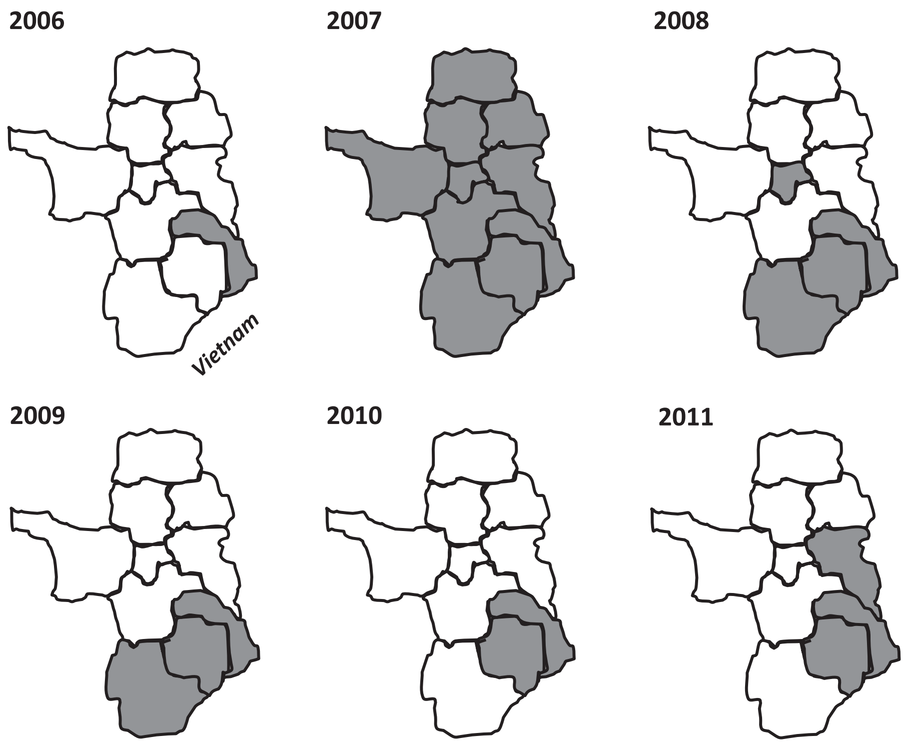

Fig. 2. Brown planthopper (BPH) damage in Takeo province from 2006 to 2011
Gray: districts damaged by BPH.

Table 1. The top 5 rice varieties cultivated in the R, CT, and PR communes

Commune	2006			2007			2008			2009			2010			2011		
	Variety		% of users	Variety		% of users	Variety		% of users	Variety		% of users	Variety		% of users	Variety		% of users
*1	*2		*3															
R (110)	Dn	L	60.9	Dn	L	61.8	Dn	L	61.8	Dn	L	61.8	Dn	L	61.8	Dn	L	61.8
	6K	L	14.5	6K	L	15.5	Sb	M	16.4	Tls	L	20.9	Tls	L	31.8	Tls	L	40.0
	No	M	14.5	No	M	14.5	6K	L	15.5	Ss	L	16.4	No	M	17.3	No	M	21.8
	Tls	L	13.6	Tls	L	14.5	Ss	L	15.5	No	M	16.4	Ss	L	16.4	6K	L	18.2
	Ss	L	12.7	Ss	L	14.5	No	M	15.5	Sb	L	15.5	6K	L	15.5	Ss	L	16.4
				Sb	M	14.5							Sb	L	15.5	Prl	M	16.4
CT (179)	Dn	L	71.5	Dn	L	71.5	Dn	L	71.5	Dn	L	71.5	Dn	L	71.5	Dn	L	71.5
	IR66	E	59.8	IR66	E	61.5	IR66	E	63.7	IR66	E	64.8	IR66	E	68.2	IR66	E	68.2
	Tls	L	57.0	Tls	L	59.2	Tls	L	59.8	Tls	L	60.3	Tls	L	62.0	Tls	L	64.2
	No	M	43.0	No	M	43.0	No	M	45.3	No	M	45.8	No	M	45.3	No	M	45.3
	Dn	M	26.3	Dn	M	26.3	Dn	M	26.3	J	M	27.9	J	M	27.9	J	M	29.1
PR (127)	Dn	L	66.1	Dn	L	66.1	Dn	L	66.1	Dn	L	66.1	IR504	E	76.4	IR504	E	85.8
	Nm	L	50.4	Nm	L	50.4	Nm	L	51.2	IR504	E	55.9	Dn	L	66.1	Dn	L	66.1
	Si	L	48.0	Si	L	48.0	Si	L	48.8	Nm	L	50.4	Nm	L	50.4	Si	L	51.2
	IR504	E	25.2	IR504	E	30.7	IR504	E	36.2	Si	L	48.0	Si	L	49.6	Nm	L	50.4
	Ak	L	13.4	Ak	L	14.2	Ak	L	15.0	Ak	L	15.0	Ckl	L	18.9	Ckl	L	21.3

*1 Parentheses show the number of participants.
*2 Rice varieties: L, late-maturing; M, mid-maturing; E, early-maturing.
L; Dn (Domnarb), 6K (6 kour), Tls (Tom leak sleak), Ss (Srov Sor) Nm (Neang Minh), Si (Si Sol), Ckl (Chhung kung leak), Ak (Angkong), Sb (Sor Bronab), M; No (No Name), Dn (Domnarb), J (Jasmin), Plr (Prong Lolork), E; IR66 (IR66), IR504 (IR504.04).
*3 The percentage of users was calculated based on the number of farmers that cultivated each variety divided by the number of participants.

farmers) obtained from 530 participants for the analysis (78.5%).

(1) Major rice varieties

The top 5 cultivated rice varieties from 2006 to 2011 are shown in Table 1. In all 3 communes, late (L) maturing varieties were primarily cultivated, whereas the specific varieties were cultivated to different extents in each commune. However, the major rice varieties used in each commune followed the same order of ranking during the 6 years, except for IR504.04 in PR-commune, the cultivation of which has soared over the 6-year period (Table 1).

(2) Rice planting schedule

In general, the rainy season begins in mid-April, with the rainfall increasing until October[13]. Farmers started to sow early (E) maturing varieties from May to June and harvested these crops in August to September (E1). In comparison, farmers started planting late (L) and medium (M) maturing varieties from June to July and harvested them in November/December, although slight differences were noted among the methods used by the farmers. In the PR-commune, early (E) maturing varieties were also cultivated from the end of the rainy season to the beginning of the dry season, from October to January (E2) (Fig. 3). This behavior indicates the farmers in the target area mainly cultivated rice during the rainy season.

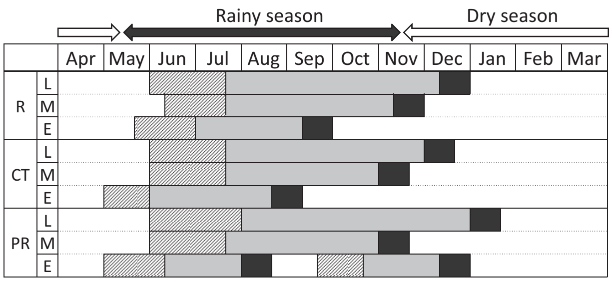

Fig. 3. Annual Rice planting schedule in R, CT, and PR communes

*1 Rice varieties: late- (L), mid- (M), and early- (E) maturing varieties. *2 Rice-growing stages: diagonal-lined square, seedling stage; gray square, growing stage; black square, harvest stage.

(3) Recognition of rice planthopper damage by farmers

The farmers were interviewed about the rice plants that died because of symptoms similar to hopperburns, with questions asked about the year, variety, rice-growth stage, and extent of damage. The responses of the farmers were confirmed based on whether they recognized the small insects at the bottom of the rice stems in photographs of BPH and hopperburn, despite the difficulty in identifying specific rice planthopper species.

Table 2. Farmers' recognition of BPH-damage

Commune	*1	R (110)							CT (179)							PR (127)						
Year	Variety *2		*3BT		BF		BH			BT		BF		BH			BT		BF		BH	
		*4S	A	B	A	B	A	B	S	A	B	A	B	A	B	S	A	B	A	B	A	B
2006	L	**100**	0	0	7	0	0	0	**174**	9	12	16	9	0	0	**124**	1	6	15	16	0	0
	M	**38**	0	0	0	0	0	0	**149**	13	6	16	8	4	0	**11**	0	0	0	0	0	0
	E1	**15**	0	0	0	0	0	0	**107**	0		0	0	0	0	**33**	1	0	0	0	0	0
	E2	**-**							**-**							**-**	0	0	0	0	0	0
2007	L	**105**	7	15	5	19	0	0	**174**	6	21	23	34	0	0	**124**	11	19	34	42	0	0
	M	**40**	0	0	0	0	0	0	**156**	1	10	1	16	0	0	**12**	0	0	1	3	0	0
	E1	**15**	0	0	0	0	0	0	**111**	0	3	0	9	0	0	**40**	13	0	0	0	0	0
	E2	**-**							**-**							**-**	0	5	0	0	0	0
2008	L	**105**	11	16	10	18	0	0	**174**	0	28	25	30	0	0	**124**	26	23	21	56	0	0
	M	**47**	5	2	7	0	0	0	**163**	0	11	4	17	0	0	**12**	0	1	0	7	0	0
	E1	**15**	0	4	3	0	0	0	**115**	0	0	1	0	0	0	**48**	9	3	5	19	0	0
	E2	**-**							**-**							**-**	0	5	0	6	0	0
2009	L	**104**	9	30	35	27	0	0	**175**	10	37	36	42	1	2	**124**	25	43	28	88	0	0
	M	**50**	0	16	11	23	0	0	**172**	7	10	19	11	0	2	**14**	0	1	0	7	0	0
	E1	**15**	0	5	5	0	0	0	**117**	0	1	0	4	0	0	**78**	12	14	1	35	0	0
	E2	**-**							**-**							**-**	2	6	0	11	0	0
2010	L	**106**	6	20	17	16	0	0	**174**	0	23	0	20	0	0	**126**	7	54	5	87	0	6
	M	**58**	0	8	9	2	0	0	**172**	3	4	0	5	1	0	**16**	1	0	2	3	0	0
	E1	**15**	0	0	1	0	0	0	**122**	0	0	0	5	0	0	**109**	1	32	0	42	0	0
	E2	**-**							**-**							**-**	4	9	0	11	0	0
2011	L	**106**	0	22	0	26	0	0	**175**	5	19	0	23	0	0	**124**	1	53	0	84	0	0
	M	**67**	0	8	0	4	0	1	**173**	0	4	0	5	0	0	**19**	0	1	0	6	0	0
	E1	**14**	0	5	0	0	0	0	**123**	0	0	0	0	0	0	**121**	1	33	0	42	0	6
	E2	**0**							**0**							**75**	2	10	0	11	0	0

*1 Parentheses show the number of participants.
*2 Rice varieties: L, late; M, medium; E, early-maturing varieties (E1/E2: 1st and 2nd cropping). The number of farmers that cultivated E2 before 2010 was not obtained.
*3 Rice-growing stages: BT, before transplant; BF, before-lowering; BH, before harvesting.
*4 S: The number of farmers that grew each variety (L, M, and E). A: The number of farmers that observed BPH damage in over 50% of the area. B: The number of farmers that observed BPH damage in less than 50% of the area.
*5 Statistical analyses are shown in Table 3.

The results of the above questions are shown in Tables 2 and 3. In terms of commune location, farmers from the PR-commune, which is located next to Vietnam, recognized rice planthopper damage to a greater extent compared to that by farmers from the other communes. When comparing the responses of farmers from R- and CT-communes, more farmers from R-commune observed damage in over half their fields (A-damage) compared to that by farmers from CT-commune (Partial regression coefficient: R, -0.53 [$P < 0.001$]; CT, -0.85 [$P < 0.001$]).

In 2008–2009, a significantly larger amount of damage was recognized by farmers compared to that in other years (A-damage) (Partial regression coefficient: 2008, 0.43 [$P < 0.01$]; 2009, 0.85 [$P < 0.001$]). However, the amount of damage decreased after 2010, with an increase in the number of farmers recognizing damage in less than half the area (B-damage) (Partial regression coefficient [A/B-damage]: 2010, -0.67 [$P < 0.001$]/2.98 [$P < 0.001$]; 2011, -2.63 [$P < 0.001$]/3.03 [$P < 0.001$]). However, particularly in the PR-commune, more than 40% of farmers continued to experience a low level of annual damage by BPH (Table 2).

Late (L) and medium (M) maturing varieties were recognized varieties that were damaged by BPH compared to early (E) maturing varieties, although their susceptibility was not clearly established (Partial regression coefficient [A/B-damage]: L, 1.41 [$P < 0.001$]/0.14 [$P < 0.01$]; M, 0.54 [$P < 0.001$]/0.16 [no significance]). In addition, more farmers recognized BPH-damage in crops during the period before the transplanting stage (BT) to before the flowering (BF) stage (Partial regression coefficient [A/B-damage]: BT, 3.75 [$P < 0.001$]/3.95 [$P < 0.001$]; BF, 4.37 [$P < 0.001$]/4.31 [$P<0.001$]). Notably, almost no farmer recognized the presence of BPH before-harvesting (BH). During the second planting of early-maturing varieties in PR-commune, a few farmers recognized BPH-damage (Table 2).

Discussion

In this study, we determined the current status of BPH-damage in Cambodia in relation to damaged area, year, rice

Table 3. Relationship between brown planthopper (BPH) damage and each factor

Independent variables	A-damage *1		B-damage	
	PRC *2	Significance *3	PRC	Significance
R-commune	-0.53	***	-0.63	***
CT-commune	-0.85	***	-0.62	***
PR-commune	-		-	
L-varieties *4	1.41	***	0.14	***
M-varieties	0.54	**	0.16	
E-varieties	-		-	
BT *5	3.75	***	3.95	***
BF	4.37	***	4.31	***
BH	-		-	
2006	-		-	
2007	0.26		1.39	***
2008	0.43	**	1.70	***
2009	0.85	***	2.30	***
2010	-0.67	***	2.98	***
2011	-2.63	***	3.03	***
R-commune*2010	-		-1.29	***
R-commune*2011	-		-0.89	***
CT-commune*2010	-		-1.81	***
CT-commune*2011	-		-1.97	***
Constant	-7.53	***	-8.09	***
Sample size	14946		14946	
Pseudo-R^2	0.20		0.26	

(Data were analyzed by logistic regression analysis)
*1 Extent of damage: A-damage, BPH-damage in over 50% of the area; B-damage, BPH-damage in less than 50% of the area.
*2 PRC: partial regression coefficient.
*3 *P<0.05, **P<0.01, ***P<0.001
*4 Rice varieties: L, late-maturing; M, mid-maturing; E, early-maturing.
*5 Rice-growth stages: BT, before transplant; BF, before flowering; BH, before harvesting.

variety, and rice-growth stage. Severe BPH-damage might be more likely to be observed in the area (or specific provinces) of Cambodia near Vietnam. In comparison, the outbreak of BPH occurred in the southern part of Vietnam during 2007–2009, but decreased after 2010. The farmers in Cambodia recognized BPH-damage from 2008–2009, with this damage also recognized by Cambodian governmental officials as occurring since 2007. The recognition of BPH by both parties (officials and farmers) indicates that BPH occurrence in Cambodia was synchronized with that in the southern part of Vietnam; however, the relationship of BPH occurrence in the 2 countries requires validation.

BPH-migration depends on wind direction[14]. In the Indochina peninsula, the prevailing wind tends to be southerly during the rainy season and northerly during the dry season respectively. From April to May, the harvesting of winter-spring crops starts in the southern part of Vietnam[15], while the sowing of early-maturing varieties begins in Cambodia (Fig. 3). This season seems to influence the movement of BPH from the southern part of Vietnam to nearby areas of Cambodia, even though the population of BPH-migrants tends to vary annually. The farmers observed damage to late and mid-maturing varieties at the growing stage pre- and post-transplanting, in around July to September (Tables 2, 3). These observations indicated that high BPH population densities occurred in the fields of late and mid-maturing varieties before the flowering stage. In Southeast Asia, the life cycle of BPH is completed in 3–4 weeks[10,11]; hence, the population of early-maturing varieties might increase when late and medium maturing varieties are planted. BPH might initially inhabit early-maturing varieties in the harvested fields of dry-season crops or migrate from elsewhere such as the southern part of Vietnam; however, the source area of migrants requires identification to implement efficient control.

Understanding the relationship between BPH occurrence in Vietnam and Cambodia and determining the source area from which BPH migrate are expected to help facilitate efforts to effectively control BPH populations in the Mekong Delta area.

Acknowledgments

We thank Drs. Preap Visarto of the GDA and Ho Van

Chien of the Southern Regional Protection Centre in Vietnam for providing useful information and advice. We also thank Ms. Hing Thida and Messrs. Var Sophal, and Yam Vin of the Royal University of Agriculture for translations during the survey. We thank Dr. Shinsaku Nakajima of Meiji University for conducting the statistical analysis. Additionally, we thank all the participants of this study.

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