CARDI Research Project Report
Volume 3, 2010

Implementation **P**lans to **D**isseminate **S**ubmergence **T**olerant **R**ice **V**arieties and **A**ssociated new **P**roduction **P**ractices to **S**outheast **A**sia: **C**ambodia

PROJECT FINAL REPORT: CAMBODIA
Implementation plans to disseminate submergence tolerant rice varieties and associated new production practices to Southeast Asia

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Rice is a staple food for Cambodia and grows on about 80% of total area of agricultural crops. Rainfed lowland ecosystem is predominant capturing approximate 82% of the total rice area. Although the yield and production of rainfed lowland rice have been significantly increased during the 15 years, but this increase is not stable depending mainly on erratic and unpredictable rainfall. One of the major constraints in this ecosystem is flood which can completely damage rice area up to 20%, and lower the national yield by 10%.

Two provinces (Kampong Thom and Pursat) frequently affected by flood and field experiment at the Cambodian Agricultural Research and Development Institute (CARDI) have been selected for testing the performance of submergence tolerant breeding lines and Sub1 mega varieties developed by IRRI, baseline survey and breeding activities from mid 2007 to December 2009 using Japan-ADB supported budget under the project called *Implementation plans to disseminate submergence tolerant rice varieties and associated new production practices to Southeast Asia* leaded by IRRI.

Flood occurs almost every year at the country level. Result obtained from 215 interviewed farmers and 10 farmer-village groups in 22 villages of Kampong Thom and Pursat shows that the medium and lower toposequence fields of rainfed lowlands experiences possibly 2-3 times flood in most of the years. Flood depth varies from 1.5-2.0 m with 15-30 days period. In flooding year, rainfed lowland rice yield in Kampong Thom can be reduced by 70% and in Pursat by 37% of the succeeded year. To address with flooding farmers (92%) preferred rice varieties that are tolerant to submergence. Farmers also reported that Phka Rumduol performs good under submerged conditions.

Six different experiments were conducted to evaluate performance of more than 100 breeding lines developed by IRRI, including mega Sub1 varieties, and Cambodian genotypes, including CARDI's released varieties. The mega Sub1 varieties and some of CARDI's released varieties (Phka Rumduol, Phka Romeat, Riang Chey, CAR9) performed well under submerged conditions of 14 days. However, all mega Sub 1 varieties are semi-dwarf and insensitive to photoperiod with 115-140 days maturing are not suited to the flood-prone rainfed lowland area where water depth of 30-50 cm can be stagnated in the fields for at least a month. Therefore, seven populations (BC1F2=2, BC2F1=5) have been developed by incorporating Sub1 gene from IR64-Sub1 into five popular varieties released by CARDI for rainfed lowland conditions using conventional backcrossing method.

EXECUTIVE SUMMARY

Situated in Southeast Asia with monsoonal climate, Cambodia is a rice country as rice covers about 80% of the total cultivated area of agricultural crops. About 82% of rice is grown in rainfed lowland and the rest is in rainfed upland, deepwater and dry season ecosystems. Rice improvement has been re-started since 1989 with 38 improved varieties have been released so far, and national yield and production markedly increased since

1995. However, this increase is not stable as rainfed lowland rice productivity is mainly dominated by rainfall which is erratic and unpredictable. Together with drought, flood occurs every year with different incidence and severity. For example in 2000, flood completely damaged about 20% of the rainfed lowland rice area but the rest was not much affected with national harvested yield was 1.95 t/ha. In 2002, flood completely damaged only 4.66% of rainfed lowland rice area while most of the rest was affected with reducing national harvested yield to 1.70 t/ha. Thus, flood is one of the main factors challenging rice improvement for rainfed lowland ecosystem of Cambodia.

In 1990's, more than 6000 rice samples have been collected throughout the country and 2557 accessions (88% are rainfed lowland rice) have been conserved at CARDI, for short-term storage, and at IRRI, for long-term storage after evaluation and characterization. Most of local rice accessions are strongly sensitive (63%), while essentially sensitive are 31%, essentially-slightly sensitive are 4.5% and strongly insensitive are 1.7%. About 1/3 of accessions that perform well during evaluation were mass or pure line selected and widely tested over country and as the results, 17 improved rice varieties have been released for rainfed lowland ecosystems. Among these varieties, some are well adopted by the farmers, consumers and traders.

There are three maturing groups of rice growing in three different toposequence of rainfed lowlands and they are (i) early maturing group flowers before mid October suited for high toposequence fields, (ii) intermediate maturing group flowers during mid October to mid November suited for medium toposequence fields and (iii) late maturing group flower later than mid November suited for lower toposequence fields. Detail water growing conditions and phenology of rice are well described in Ouk Makara *et al.* (1995). The medium and lower toposequence fields are flood prone area and cover about 80% of total rainfed lowland area.

The IRRI-Japan Project has succeeded in introgressing of Sub 1 gene into six mega varieties (Samba Mahsuri, Swarna, BR11, IR64, TDK1 and CR1009) which can be tolerated under submerged water up to 14 days. Five introgressing mega varieties (except TDK1-Sub1) are insensitive to photoperiod with early to intermediate maturing (115-140 days) and have semi-dwarf plant type. Dissemination of these Sub1 varieties in farmer's fields in the Asian countries is a main challenge of the *Implementation plans to disseminate submergence tolerant rice varieties and associated new production practices to Southeast Asia Project* (July 2007-December 2009) which is the third phase continued from the previous introgression and testing phases.

As institute just involves in the 3rd phase project and base on the growing conditions of flood-prone rainfed lowlands of Cambodia, the Cambodian Agricultural Research and Development Institute (CARDI) undertakes (i) Assessment of production damage from flood (ii) baseline survey for technological information on rice grown in flood-prone areas, (iii) introgression of Sub1 gene from IR64-Sub1 into popular released varieties, (iv) initial testing Sub1 materials developed by IRRI and local materials, (v) farmer field day preference analysis, (vi) seed multiplication of Sub1 materials and (vii) capacity building through training and workshop.

Assessment of production damage from flood: flood damaged rainfed lowland rice in 10 years out of 11 years (1995-2005). Area completed damaged by flood varied from 0.2% in 2005 to 19.5% in 2002 with an average of 5% of 1.95 million hectares (excluding 1996). Beside rice rotten, flood also could reduce national yield of rainfed lowland by up to 10% of the succeeded previous year. In Pursat, three out of six districts experienced flood in 5 to 7 years from 1999-2007. Results obtained from baseline survey conducted with 215 farmers in Kampong Thom and Pursat indicate that villages located in medium and lower toposequence experienced flood most years with possibly 2-3 times flooding per year and 1.5-2.0 m depth. Flood lasts for 15 days or even up to 30 days in Kampong Thom.

Baseline survey for technological information on rice grown in flood-prone areas: baseline survey and village workshop have been conducted in five villages in Kampong Thom and in 17 villages in Pursat. There were 111 farmers and five village workshops in Kampong Thom, and 104 farmers and seven village workshops have been interviewed and conducted. Village size in Kampong Thom ranges from 110 to 500 households with 2-3 times larger than in Pursat (50-140 households). Farmers in both provinces reported that they own in average of 1.6 ha in Kampong Thom and 1.5 ha in Pursat with 2-3 rice parcels located in different direction of households. Flood frequency in last 10 years was one every two years. In Kampong Thom, 17% of cultivated area was affected by submergence and can be prolonged up to 30 days reducing yield by 70% of the succeeding year, while in Pursat, 29% suffered submergence and 46% experienced deep flash flood lasted in maximum of 15 days with yield reduction of about 37%. Although some farmers reported in changing some of cultural practices to cope with the flood, but 92% of interviewed farmers prefer rice varieties tolerating to submergence. Beside that some farmers say that Phka Romduol performs better to some extent of flood.

Introgression of Sub1 gene from IR64-Sub1 into popular released varieties: two populations (CAR6 and Phka Romduol) of BC1F2 using IR64-Sub1 as recurrent, and five BC2F1 population using IR64-Sub1 as Sub1 gene donor and Phka Rumduol, CAR6, Riang Chey, Phka Romeat and Phka Chan Sen Sar as recurrent have been produced. These populations will be continued developed and selected.

Initial testing Sub1 materials and farmer field day preference analysis: more than 100 genotypes introduced from IRRI and local materials have been tested in six experiments. In year 2008, two sets of genotypes (set I=71 genotypes and set II=36 genotypes) have been screened at CARDI's flooded field for different submerged treatments using PVC tube; and on-farm trial at 26 locations in Kampong Thom and Pursat with 2-3 mega genotypes compared with farmer's varieties. In 2009, three experiments have been conducted at CARDI (flooded and irrigated conditions with 36 genotypes, five did not germinated) and at Kampong Thom with 24 genotypes. Result obtained from all types of experiments for common genotypes is summarized in Table 1.

Genotype performance under flooded conditions is not stable. This unstable performance might caused by differences in time, period and water level of flooding. However, some of mega-sub1 varieties and CARDI's released varieties showed promising under completely submerged conditions with relatively good grain yield after recovering. In general, genotypes that survive in higher rate after flooding produced higher grain yield ($y=0.03x+0.4$; $R^2=0.64$) and this survival rate may associated with plant height ($y=0.51x-26.3$; $R^2=0.64$). Under non-flooded conditions at Kampong Thom in 2008 (KT081), most of farmers preferred Phka Rumduol, but when the crops was submerged at Kampong Thom 2009 (KT09), more farmers preferred IR54517 as it recovered well. A submerged pond has established at CARDI in 2009 and will be used for further submerged screening purposes.

Table 1. Summary performance of common rice genotypes tested under different experiments (2008-2009).

Genotype	C09I	KT09		C09F	SetI	SetII	OFAT	Farmer preference score		
	Y	SP	Y	SP	14D	15D	Y,WG1	KT081	KT082	KT09
IR 05F102 (Swarna-Sub1)	3.43	58	2.27	0	5	na	0.00	(0.14)	0.18	(1.00)
IR 07F290 (BR11-Sub1)	3.10	48	2.28	0	5	na	0.00	na	na	(0.75)
IR 07F287 (Samba Mahsuri-Sub1)	2.53	58	1.62	0	na	na	0.00	(0.05)	(0.08)	na
IR 07F102 (IR64-Sub1)	1.99	25	1.47	0	5	5.0	0.33	(0.22)	na	na
Phka Romeat	2.55	68	2.45	13	5	7.5	na	na	na	(1.00)
Phka Rumduol	2.39	68	2.33	9	5	7.0	na	0.41	na	(0.70)
Raing Chey	4.10	53	2.33	11	5	7.5	na	na	na	(0.80)
CAR 9	3.89	17	0.80	8	5	5.0	na	na	na	na
IR 51514-PMI-5-B-1-2	na	75	2.47	na	na	na	na	na	na	(0.10)

C09I=CARDI-Irrigated 2009, KT09=Kampong Thom 2009, C09F=CARDI-flooded 2009, OFAT=on-farm adapted trial, KT081=Kampong Thom 2008 at farmer's field day 1, KT082= Kampong Thom 2008 at farmer's field day 2, Y=grain yield (t/ha), SP=survival plants (%), D=day, WG1=water level group 1, na=not applicable data.

Seed multiplication of Sub1 materials: seeds of Samba-Mahsuri-Sub1, IR64-Sub1, Swarna-Sub1 and BR11-Sub1 have been multiplied for three times since September 2007 with a total 1425 kg of seeds for mainly experiment purpose. During multiplication, crop was affected by BPH carrying virus causing grassy stunt disease with lower incidence in BR11-Sub1 (5%) and Swarna-Sub1 (11%), and high in Samba-Mahsuri-Sub1 (30%) and IR64-Sub1 (28%).

Capacity building through training and workshop: the project provided training courses on (i) Laying the foundation for the 2nd green revolution (ii) MAS for submergence tolerant (iii) Data management and analysis training-workshop for the socioeconomic (iv) Participatory Approach to Up Scaling the Adoption of Submergence Tolerant Rice" and (v) Introduction of GIS for six CARDI's staff and two provincial agricultural department staff.

RESEARCHER/PROJECT STAFF AND DESIGNATION

1. Cambodian Agricultural Research and development institute (CARDI)

Dr Ouk Makara	Deputy Director and Director affected from February 2009
Mrs Sakhan Sophany	Head of Plant Breeding Division
Mr Chea Sareth	Acting Deputy Head of Socio-economic Sciences Division

Mr Touch Veasna	Deputy Head of Soil and Water Sciences Division
Ms Ouk Sothea	Research assistant, Plant Breeding Division
Mr Yav Kimsoth	Research assistant, Plant Breeding Division
Mr Nou Kihen	Research assistant, Plant Breeding Division
Mr Sam Sonith	Technician, Plant Breeding Division
Dr Khun Leang Hak	Researcher, Plant Breeding, affected until mid 2008
Mr Chou Vichet	Research assistant, Plant Breeding, affected until

2. Kampong Thom Department of Agronomy

Mr Ou Boss Phaon	Director, Provincial Department of Agriculture
Mr Thiv Vanthy	Deputy Director, Provincial Department of Agriculture, affected from January 2009.
Mr Van Sithan	Agronomist, Provincial Department of Agriculture.
Mr Vath Kimcheang	Agronomist, Provincial Department of Agriculture.

3. Pursat Department of Agriculture

Mr Thiv Vanthy	Deputy Director, Provincial Department of Agriculture, affected until 2008.

IMPLEMENTING AGENCIES

Cambodian Agricultural Research and Development Institute

INTRODUCTION

Cambodia is situated in Southeast Asia. It occupies a compact territory covering 181 035 km^2. The country extends in latitude from 10º to 15º north and in longitude from 102º to108º east. Situated in the tropics, Cambodia experiences monsoonal climate with distinct wet and dry season. The wet season extends from May to October, while the dry season runs from November to April. The means of temperatures range from 21 to 35 ºC, with the highest temperature in April (30-35ºC) and the lowest in the January (21-25 ºC). Most rice-growing areas receive between 1250 and 1750 mm rainfall annually (Ouk Makara et al., 2001).

Rice is the most important crop and is cultivated in both wet and dry seasons. In the wet season, it is grown in different agro-ecosystems, ranging from rainfed uplands, where there is no standing water in the fields, to rainfed lowlands and deep water where water can be 4–5 m deep (Ouk Makara et al., 1995; Men Sarom et al., 2001). Dry-season rice may receive either full or supplementary irrigation, or be broadcasted or transplanted as floodwaters recede, receiving little or no irrigation. 'Recession rice' is commonly practised in areas around lakes or where deepwater/floating rice has been grown.

For such a distinct agro-ecosystems, there are thousands of local varieties have been grown by farmers (Sahai et al., 1992a,b; Javier et al., 1999), indicating that there is no single variety that can be adapted to all these agro-ecosystems. Moreover, these varieties are mainly low yielding and impure population. Post-war improvement of rice through breeding program has been started from 1989. Since its establishment, rice breeding program has enormously contributed to the increase of rice productivity with an achievement of self-sufficiency in 1995 for the first time since 1970 (Ouk Makara et al., 2001). Rice production has been increased from 2.50 million tons in 1990 to 6.72 million tons in 2007. These increases are commensurate with an increase in the rice research effort. Chaudhary and Papademetriou (1999) reported that, during 1987 to 1997, the country's rice production growth rate was as high as 4.4%, compared with 1.8% for Asia overall. Such success is partly contributed by the release of 37 improved rice varieties from the Plant-Breeding Program of the Cambodia-IRRI-Australia Project (1989-1999) and the Cambodian Agricultural Research and Development Institute (CARDI, 1999-presence).

Rainfed lowland rice is predominant in Cambodia with more than 80% of the total rice growing area. In this ecosystem, rainfall is extremely erratic and short-term flood/flash flood may occur during any of these months. Excessive rains in September to October, coupled with the high floodwater level in the Tonle-Bassac and Mekong rivers, can cause widespread flooding in the rainfed lowlands (Ouk Makara et al., 1995). This effect is greatest in the lower parts of the toposequence. The strong currents associated with the flash floods laden with silt can damage leaves and submerge the crop for a number of days.

Severity of flood varies from year to year. In the 2000 wet season, 20% of 2.06 million hectares (MAFF, 2001) and in 2001 wet season 10% of 1.93 million hectares (MAFF, 2002) of rainfed lowland rice was completely lost by flood (Table 2). In 2002, flood completely damaged only 4.66% of 1.82 million hectares of rainfed lowland rice area, but it affected to most parts of the country resulting in national yield reduction by about 10% of the yield in 2001 (MAFF, 2003). Thus, to minimize reduction of rice production by flood is the challenge of the Plant Breeding Program.

Table 2. Total rainfed lowland rice and areas damaged by flood from 1995 to 2005.

Year	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total area (Mha)	1.87	1.83	1.87	1.92	2.06	1.93	1.82	2.03	2.05	2.11
Damaged area (%)	7.87	2.13	1.63	2.63	19.50	10.21	4.66	0.18	0.54	0.98

Sources: MAFF, 1996-2006.

OBJECTIVES

The IRRI-Japan Project has developed submergence-tolerant rice varieties (rice varieties with the sub1 gene), and now, truing to disseminate such varieties and their associated new production practices to South East Asia, through project titled "*Implementation plans to disseminate submergence tolerant rice varieties and associated new production practices to Southeast Asia*". Involving with this project, the Cambodian Agricultural Research and Development Institute (CARDI) has implemented five main activities including (i) Modeling and analysis to create recommendation domains and estimate potential economic benefits, (ii) Submergence tolerant rice varieties in Cambodia: socio-economic and technological information on rice grown in flood-prone areas, (iii) Initial testing Sub1 materials developed by IRRI and incorporating Sub1 existing in IRRI's materials into the popular Cambodian varieties and (iv) Seed Multiplication of Sub 1 Rice Varieties.

PROJECT SITE (S) AND RESEARCH TEAM

Project site: Cambodian Agricultural Research Institute (CARDI)
Kampong Thom province
Pursat province

PART 1. CHARACTERIZING SUBMERGENCE CONDITIONS IN RICE AREAS

During the 2nd week of August 2007, the team visited Kampong Thom and Pursat for selection of target areas. In Kampong Thom, Dr Ouk Makara and Dr Khun Leang Hak accompanied by Dr Labios Romeo meet Mr Noch Mangdy, Head of Agronomy Office of Provincial Department of Agriculture on 14th August to brief the purpose of the project and identify the most affected district by flood. Fortunately, there was a flood in Steung Sen and Kampong Svay districts for about one week already, so we went there to observe the flood. After talking with several farmers, we decided to select Steung Sen district for testing the Sub1 varieties developed by IRRI and to conduct survey.

The CARDI's team (Dr Ouk Makara, Mr Chea Sareth and Mr Touch Veasna) visited Provincial Department of Agriculture in Pursat and met Mr Thorng Sotat, Deputy Director; Mr Phang Sivuth, Deputy Head of Agronomy Office on 17th December, 2007 to brief the purpose of the project and collect secondary data of flood in order to identify the most flood prone district. Base on the seven years data (Table 3), Kandieng district was identified as the most affected area by flood followed by Bakan. Therefore, we decided to select Kandieng as target area. The following day, the team went to Kandieng and met Mr Mom Sok, Head of district agricultural office. After meeting, the team visited two communes (Anlong Vill and Veal). After talking with farmers about the flood, we decided to select both communes for the target area.

Table 3. Damaged rice area (ha) by flood in six districts in Pursat for seven years.

District	1999	2000	2001	2002	2003	2006	2007	Total	Frequency
Bakan	0	1,043	0	6,461	9,424	1,683	186	18,797	5
Kandieng	950	2,187	2,270	4,415	7,831	2,347	1,193	21,193	7
Krakor	0	0	0	758	2,421	398	0	3,577	3
Kravanh	0	0	0	0	0	1,217	0	1,217	1
Sampov Meas	136	792	0	794	1,050	3,160	0	5,932	5
Veal Veng	30	0	0	0	0	100	0	130	1
Total	1,116	4,022	2,270	12,428	20,726	8,905	1,379	50,846	

Results obtained from 111 famers from 5 villages of Stung Sen district in Kampong Thom and 104 farmers from 17 villages of Kandieng and Sampov Meas districts in Pursat indicate that four villages experienced flood most year, three villages had no recently flood problem and the rest reported specific years of flooding. September, October and August were the common flood months and once a year was the most record though 2 to 3 times were also possible. Flood duration in Kampong Thom has lasted for quite long between 15 to 60 days but it seemed to be short in Pursat, normally one week. The depth of flood was fairly consistent, commonly 2 metres but few cases of 1.5 metres.

PART II. FARMER LOSSES AND FARMER'S COPING MECHANISMS

2.1. Introduction

The project sites were conducted in two different provinces of Cambodia, Kampong Thom and Pursat provinces. Kampong Thom, central of the country and Pursat, western part, the provinces are divided by the Tonle Sap great lake, the former province in the east and the latter in the west. The two locations have been strongly influenced by water regime of the great lake. The areas were vulnerable to flood caused by both annual regular water rise and natural disaster such as storm and torrential rainfall occurred in wet season. The areas have been predominant by rainfed wet season rice and deepwater rice specially paddy fields next to the great lake.

Understanding the main village characteristics and influenced factors to the project sites would be necessary to contribute to both project's implement and achievement. The project of dissemination of submergence-tolerant rice varieties and associated new production strategies would be suitable only for the areas where rice crops are always ruined by flush flood. We try to analyse such different factors as farm, human and natural resources which closely related the rice production. The flood was likely the key constraints to rice production but farm resources are also important factors influenced the production input costs and management practices. More importantly, farmers who faced the constraint and manage the problem are the decision makers regarding adoption of technologies so they are essential factor.

Pre-project analysis of the sites would not only attribute to the success of implementing the project but also establish a sustainability of technology adoption. The output of preliminary study can be a very useful to guide the work more effective in the project implementation though it would not a final conclusion or recommendation. The results of analysis can be also used to modify or improve the project objectives and methodologies to suit the practical situation if they are not applicable. Therefore, preliminary analysis of relevant factors would be desperately required.

A baseline survey and village workshop, considerably effective approaches to obtain basic farm information specially collecting general situations of the sites were conducted in the villages of project sites to analyse the typical situations which closely relates to the dissemination of submergence tolerant varieties. The studies focused on certain information of the key factors mentioned, such as village and household background, farmland holding with different crop production, farmers' cultural practices, farmers' management practices toward flood occurrence, family labour management, seasonal climate and cropping patterns.

2.2. Characteristics of studied farm households and villages

The total of 215 farm houses from the two provinces were conducted a baseline survey to obtained flood information, practice management to cope with flood, rice cultivation practice and other flood related socio-economic factors. There were 111 famers from 5 villages of Stung Sen district in Kampong Thom and 104 farmers from 17 villages of Kandieng and Sampov Meas districts in Pursat for the whole baseline surveys. Besides the large sample surveys, five village workshops in Kampong Thom and seven village workshops in Pursat were carried out in the same villages of baseline surveys. Furthermore, two farmer field days for assessment of flood tolerant rice variety preferences were organized in Kampong Thom province.

The five villages selected for farmer workshops in Kampong Thom province are located in only Stoeung Sen district but they are in different three communes. Since the provincial town is under Stoeung Sen district's territory, the distance of each village to provincial market is considerably closed. Three villages of Srar Yov commune are around 10 Km from the town centre, while other two villages, Pren and Krar Chab villages are only 6 and 3 km faraway respectively. The seven workshops conducted in Pursat province belonged to 4 communes of two districts. Geographically, they are also very close to provincial town, less than 5 Km in general, except for Phteah Kor village is 27 Km through a detour road because of an unfavourable closed distant road.

Numbers of household in each village were large variation especially in Kampong Thom, ranging from 110 to almost 500 houses. There was smaller village size with narrower variation, between 50 and 140 houses in Pursat. The population varied accordingly, the largest of over 2,000 people and the smallest of 500 people per village in Kampong Thom. The largest population for a village in Pursat was slightly more than 600 and the minimum of 250 people. The average household size for the study villages was 5.4 and dependent ratio was 0.40 who was under 16 years of age. The average age of household heads was 48 years which were almost male and their highest education was at grade 6, final year of primary school. However, there was quite large numbers of female participating in the survey, 31% and 47% of the total interviewees in Kampong Thom and Pursat respectively.

2.3. Farming and off farm activities

Concerning households cultivated rice, at least 90% of each village was rice farmers except one village in Kampong Thom and another in Pursat grew rice between 60 and 70% because the villages were adjacent to towns so they involved other busyness rather than rice. Non-rice crops were quite common for every household but Phteahkor village in Pursat was very small percentage of non-rice crops because that was flooded village so fishing was major additional source of incomes besides rice. Landless family was only minority of each village but it was surprising to have 40% and 78% of landless households in two villages. The practice of renting land for farming seemed to be carried out in every village but there was big variation between villages. There were very few practices of land exchange except for few villages and noticeably figure in Dangkea village of Pursat up to 20% of the villager.

Apart from rice and non-rice crop farming, farmers also produced incomes from other activities with different scales. Almost every family of all villages kept chicken for both home consumption and sale. Cattle raised mainly for draught power and possibly trading were more popular in Kampong Thom, nearly 80% of average villages but around 50% was in Pursat with large variation among the villages. Pig which was another animal production generating household income in the villages was raised by all villages but only one village in Kampong Thom could be estimated the figure of pig producers, 80% of villagers. Most villages in Pursat reported of keeping pig though there was just minority in few villages. Finishing would be also important for every farmer in term of daily food because the villages located close to water sources such as lakes and streams and some four villages were able to make incomes from fishing. There was no palm sugar production in Kampong Thom but it was still practised by most villages in Pursat and the work was quite popular in 3 villages. Off-farm jobs including garment factory worker and labour working abroad seemed to be important in Kampong Thom but not in Pursat.

2.4. Farming tools and facilities in villages

The availability of electricity was likely to be influenced by the location of village because only one village in Kampong Thom next to National Highway could access to electricity by 10% of villagers. However, some households in four villages in Pursat were lucky to have electricity especially up to 98% of Boeung Yea's villagers had electricity. Car battery was another energy source to light farmers' home by the majority. More number of generators was reported in Kampong Thom but not in Pursat. Nearly every village owned water pump but not large number except for surprising 142 pumps in Roka of Kampong Thom and 40 pumps in Dangkea of Pursat. Hand tractor and rice thresher were other machineries that remained very few numbers for a village and mostly non in Pursat's villages. Rice mill was available in all villages regardless more or less and big or small capacity. Kampong Thom's villages owned larger numbers of rice mill with an average of 11 machineries compared to 2 units in Pursat's villages. Village's infrastructure specially road was considered medium situation by all villages in Kampong Thom but at two villages in Pursat complained of poor condition and 3 other villages appreciated that their village roads were good enough compared to others.

2.5. Climate and cropping pattern

There was not wide variation climate between the two locations though they were distanced by the great lake of Beung Tonle Sap. According to the raining pattern or wet season period from the twelve villages workshops conducted, May and April were the most commencement time of raining except for one June in one case. The end of this wet season occurred mostly in November and October with few cases in December. We can draw a representative pattern of raining period between mid May and mid November with one or two week variations. Dry period pattern occurred in other month columns accordingly. July and August was the most representative duration of short drought constraint occurred in wet season though few cases indicated in September. The constraint was commonly last for two weeks or possibly three weeks would affect recent transplanting stage or delay transplanting time.

The cropping patterns in the villages seemed quite simple because there was no irrigation source and rice was the main crops with few additional non-rice crops. Based on the start of planting time and harvesting time, rice crop could be divided into two patterns, rainfed lowland rice or wet season rice and deep water rice. The former began in May and ended in June while the early harvesting was in November and last until December. All the villages agreed that April was the most suitable time for broadcasting deep water rice and the appropriate harvesting time was January, beginning at the end of December and possibly completing in February. Non-rice crops, mainly vegetables were cultivated mostly in dry season though there was also wet season pattern depend on favourable conditions.

2.6. Land use characteristics

Village land size of the two provinces was broadly different, an average of 560 ha in Kampong Thom but it also largely varied from 190 to 1,070 ha, while the average was only 130 ha in Pursat which was generally less than 100 ha except 546 ha of Phteah Kor village. This village land comprised of paddy field of wet season rice and deep water rice, residential area and other lands. Hence, Kampong Thom's all land use categories were larger than Pursat's in general. The average of wet season rice land and deep water rice in Kampong Thom was considerably closed, 275 ha and 228 ha respectively. The average of wet season rice area was only 49 ha while deep water area was 127 ha in Pursat though three villages occupied no deep water land but a village's land was very favourable for this rice. Average residential land and minor crop areas in Kampong Thom were nearly 60 ha and in Pursat were only 10 ha.

They almost depend on only farming activities with rice cultivation on small plot of land for their daily living. Land holding for farming was comparable between the provinces with an average of 1.6 ha in Kampong Thom and 1.5 ha in Pursat of paddy fields. But their farm lands were commonly located in 2 to 3 locations. Paddy fields in both areas were classified into three different types, lowland, medium and upper fields. The low field was predominant in Pursat occupied nearly 48% of the total land types but lower and upper field classification were similar in Kampong Thom with around 42% of the total areas. Pursat's surveyed villages would be highly suffered from flood influence due to greater areas of lower and medium field types accounting for over 70%.

The survey information indicated that almost 90% of rice cultivated areas in the project sites affected by flood. The results can confirm the geographic location information. The average maximum water depth was 133 cm and 156 cm in Kampong Thom and Pursat respectively and the frequency of flood occurrence over the last 10 years have also been fewer in the first location 4.7 against 5.3 but the flood duration was longer in Kampong Thom up to 30 days compared to 14 days in Pursat. There were 4 different flooding types, submergence, stagnant, deepwater and deep flash flood. In Kampong Thom, 17% of cultivated area was affected by submergence and 71% by deepwater flooding type but for Pursat, 29% suffered submergence and 46% experienced deep flash flood. As the two areas under the same flood source and influence, the provinces experienced flood problem in 2007 in which the first flood was July and the last flood took place in October.

2.7. Rice farming practices

In general most farmers owned paddy field less than 1 ha followed by 1-2 ha category and larger than 2 ha last. Individually, 3 villages showed that the distribution of land holding between 1 and 2 ha was owned by more households. Moreover, the majority of two villages occupied larger than 2 ha land. There was no surprised to the reported of all farmers in Pursat practised transplanting for the wet season rice because it was common practice in rainfed lowlands but more or less farmers in every village in Kampong Thom shifted to direct seeding as result of drought at early stage. Concerning deep water rice, it was contrast to wet season crop establishment method, that is, direct seeding with dry seed was generally broadcasted. Transplanting time started in July for Kampong Thom and June in Pursat which ended August or September. Farmers started to do direct seeding in April which was not very much delay especially in Pursat.

Harvesting time was done between November and December for transplanting crop and January for direct seeding but Kampong Thom farmers harvested this crop from November to January. All villages adopted CARDI varieties and traditional varieties were also cultivated. But there was no CARDI's deep water rice variety planted by the farmers and numbers of deep water varieties were not as many as wet season rice. Even though few villages indicated that deep water rice yield was the same or even higher than rainfed lowland rice but the latter's yield was generally higher.

Seed rates used by farmers for both transplanting and direct seeding seemed not consistent among the villages with wide variation between 50 to 120 kg/ha of transplanting method and the average rate was 96 kg/ha and 84 kg/ha in Kampong Thom and Pursat respectively. Seed rate of deep water rice as direct seeding practice ranged from around 100 to 240 kg/ha in Kampong Thom and even as high as 280 kg/ha in Pursat and the average between the two location was also widely different, 144 and 196 kg/ha respectively.

Though farmers transplanted with no recommendation, the spacing of transplanting was 15 to 20 cm in Kampong Thom with an average of 18 cm but it was 20 cm to 30 cm with an average of 23 cm for the second location. Numbers of plant per hill also slightly different between the two places, 7 plants/hill and 9 plants/hill accordingly. The average seedling age was 37 days in Kampong Thom but 46 days were reported by Pursat's villages. The broadcasting of dry seed on dry paddy field was the most common practice for the farmers. Seed was always stored properly for next year planting though occasionally it would be bought due to crop damage or the occurring of flood or drought after planting. Farmers allocated the largest quantity of crop grain for family consumption and small amount of seed was also necessary. Rice grain was also the feed for animal production but it would not be denied as a family cash source.

With regard to rice stubble management, there were two different practices to manage stubble between wet season and deep water paddy conditions. The former condition was commonly left for cattle grazing and eventually was incorporated by ploughing when there was a couple of raining at the early wet season for next crop but the latter was burned but it might not be necessarily done by the field owners.

Of insect problem, grasshopper was reported by every farmer in Kampong Thom but only one village in Pursat. Thrip was another insect that was identified by some villages in the two locations. Farmers could not identify the name or species but worms were indicated besides army worm. Brown spot was the only disease occurred in their crop reported by two villages in Pursat. Weeds were reported with local names or language. Rat and crap were other constraints to rice production happened at least two villages in Pursat province.

2.8. Gender division for rice production activities

Female and male of family labour have been traditionally designated to take responsible for typical activities in rice production according to power requirement. Concerning land preparation for paddy field such as ploughing and harrowing by cattle particularly male labour was the one who carried out or took responsibility for the tasks. Among the twelve villages, the majority of 8 villages confirmed that family male labour devoted 100% of the time and effort to land tillage of their owned farms that is no contribution from female at all. However, there were four villages acknowledged that female labour share 5-10% of the total time. It was common practices for farmers to work in others' farms in terms of hired labour or labour exchange and this type of performance was entirely carried out by male labour. Since most of wet season rice was transplanting practice, seedbed preparation was necessary and was noticed that female shared quite large percentage of the duty. Even though four groups indicated 100% of the task was completed by male, other villages indicated that female also hardly devoted to the work and shared equal contribution with male for some villages. It was unlikely to have female labour to carry out seedbed preparation in terms of exchanged or hired labour.

Almost all villages indicated that woman contributed more than man for pulling seedling work though there was variation among the villages but the average was 66% against 34% in Kampong Thom and 76% against 24% in Pursat. Pulling, one of the activities also was normally carried out through hired labour or exchanged labour to complete the work in shorter time. Only female worked for others' fields though few villages showed small number of male performed the task as well. Similarly, female devoted greater time for transplanting with an average of 70% to 30%. Female was also the main source of hired and exchanged labour. Concerning deep water rice, male labour shared bigger working hour than female for direct seeding work, only 2% from female in Kampong Thom and 20% from female labour in Pursat.

Man labour applied fertilizers with minor support from female and this was quite consistency in the first site, the ratio of 95% to 5%. Even male labour was greater, the female in the average of the second place, there was inconsistency among the villages, at least two villages were female dominant and equal share for a village. Pesticide application was entirely taken responsibility by male in Kampong Thom and some 5% of the task was assisted by female in Pursat. Field control including water check, bund repair and weeding were equally contributed between female and male labour specially the average was comparable in Pursat except few villages where either female or male was greater involved. These activities were generally completed by family labour rather than other sources of labour.

There was very consistency among the five villages in Kampong Thom for both group contribution to harvesting activity, that is female carried 70% and male completed another 30% of the total time. Even there were three villages indicated there was equal contribution of the two groups, the effort from female was averagely larger than male, 63% to 37% in Pursat. Female was the important labour source for hired and exchanged labour in harvesting activity and male of two villages also carried out the practice. There was not greatly different for threshing but male labour took larger ratio in average for the task specially using cattle draught power.

The post harvest activities of drying and storage seed were averagely better contributed by female in spite of assistance from male and a couple of villages in both provinces showed that it was equal contribution and even higher percentage from male. But larger ratio of transport work was carried out by male labour only few villages with equal percentage. Both groups equally shared the task of seed selection though male was slightly higher in Kampong Thom province. There was contrast between the first and second location for selling grain activity, 86% of the work carried out by female in Kampong Thom but only 44% in Pursat. Female took whole responsibility of keeping cash and preparing food and snack.

2.9. Rice production costs and input sources

There was no distinguishing between female and male labour costs for any work category such as pulling, transplanting and harvesting. The common worker day was USD 2.5 per person-day in Kampong Thom and USD 2 in Pursat. This labour rate in 2008 was high compared to previous year in 2007 which was USD 1.75 and USD 1.25 in the two places respectively. Similarly land preparation cost done by machinery was more expensive in Kampong Thom, cost USD 42 per ha and around USD 38 per ha in Pursat. The former's farmers paid USD 30 per ha and latter paid USD 20 per ha in previous year in 2007. Input shop or supply at the village level was unlikely to be available even though 1 or 2 shops found in two villages but it was just very small quantity supplies or retailed salers. Most villages formed small group or association such as money saving, woman support, poor support, farming to help each other. There was no credit institution based in the village but farmers could access financial loans through agents of different banks and credit providers from towns.

2.10. Flood constraints

Though all studied villages suffered flood, the villages were likely to experience flood in different timing according to various locations and topographies. A village in Kampong Thom and 3 villages in Pursat experienced most year. Some 3 villages indicated there was no recently flood problem, however, the rest reported specific years of flooding.

September, October and August were the common flood months and once a year was the most record though 2 to 3 times were also possible. Flood duration in Kampong Thom has lasted for quite long between 15 to 30 days but it seemed to be short in Pursat, normally one week. The depth of flood was fairly consistent, commonly 2 metres but few cases of 1.5 metres.

2.11. Rice cultivation in flood year and normal year

The total cultivated areas of all interviewed farmers in two provinces were quite closed, 176 ha in Kampong Thom and 156 ha in Pursat. There is two distinguished seasons, wet and dry seasons, in Cambodia but there was almost 100% of wet season rice in the project sites. There was small change in cultivated areas between normal and flood years which overall cultivated areas declined in flood years from 325 ha to 314 ha. Areas cultivated to modern rice variety were larger in flood year, 27% in Kampong Thom and 41% in Pursat compared to 25% and 36% in normal year respectively. But rice variety itself seemed not changing that is rice varieties were not completely replaced by other because more or less, common varieties remain existing either flood or non-flood time. There were various reasons given to adoption of new varieties but flood tolerant trait was one of a couple of strong reasons specially farmers in Pursat.

Besides rice grown area affected, rice yield was adverse affected by the flood. For normal year, overall average yield was around 1.7 t/ha in Kampong Thom and 1.9 t/ha in Pursat but the yield dropped to less than 0.5 t/ha and 1.2 t/ha respectively. If the analysis of yield loss based on modern and traditional varieties, the former variety was more favourable in the flood condition. The farmers who cultivated modern rice varieties lost around 860 kg/ha but those who planted traditional varieties lost 1,330 kg/ha in Kampong Thom. But the yield loss of modern varieties was greater than traditional varieties, 707 kg/ha and 591 kg/ha respectively in Pursat. However, this does not necessary mean modern varieties performed poorer than traditional varieties in flood year yet this is because large gap yields between the two varieties in normal year and small gap yields in flood year. Actually modern rice varieties produced higher yields in either normal or flood years that is modern variety produced 171 kg/ha higher in normal year and 56 kg/ha higher in flood year.

2.12. Input use for rice production

Farmers in both locations used fairly high seed rate, 181 kg/ha in Kampong Thom and 165 kg/ha in Pursat, compared to CARDI's recommendations of around 50 kg/ha for transplanting and 100 kg/ha for direct seeding. More than 700 kg/ha of cow manure were applied in Kampong Thom but very small amount was used in Pursat. Chemical fertilizers were also not popular in both provinces. There were two types of farming labour in the areas, shared labour and hired labours. The activities of harvest and post harvest required the highest labours, more than 50% of the total labour required in rice cultivation. Nearly 30% was needed for crop establishment and around 10% for land preparation while other activities such as fertilizer application, weeding and irrigation required less labour.

2.13. Rice management practices to cope with flood

A certain adjustment in rice management practices were carried out to cope with flood problem. Flood shifted the time for crop establishment period in Pursat but it did not affect harvesting time in either location. There was small variation of transplanting and direct seeding areas caused by flood that is areas for the two cultivation practices were almost the same between normal and flood years. There were only 5% of total households changing from transplanting to direct seeding practice but 7% preferred transplanting to direct seeding in flood year. Therefore, very small areas of establishment methods increased or decreased due to the contrast preferences among farmers. There was totally 5% establishing the crop earlier than usual but only 1% in Pursat chose to plant later.

Only 4% in Kampong and 10% in Pursat of all households increased seed rate but both locations similarly increased the amount of seed up to 98 kg/ha. Minority in Pursat, 2% of the households, opted to decrease 30kg/ha of seed rate. Some 30% and 20% of farmers in Kampong Thom and Pursat changed rice varieties. Roughly 11% of all households decided to apply fertilizers early. Only few households increased or decreased the quantity of fertilizers though the increased amount was more than 40kg/ha while the increased amount was almost 30kg/ha. There was quite large numbers who decided to resowing or replanting, 18% in Kampong Thom and 41% in Pursat if their crops were destroyed by flood at early stage.

Around 33% of the total interviewees experienced seedbed being damaged by flood and 43% expected flood would happen and manage to reserve seed for replanting or resowing due to the flood problem. About 7% of them increased labour for weeding with only extra 2 labour days for one hectare. But 3% indicated that they decreased 2 labour days per hectare. Almost no one made a decision to increase or decrease herbicides inputs. The interviewees have not heard or did not plant typical submergence-tolerant rice varieties though they were aware that some of their varieties such CARDI's released varieties as Phka Rumdoul would tolerate to flood to some extent. Interestingly, the farmers impressed by having submergence-tolerant rice varieties and as high as 92% of them are willing to adopt this variety.

2.14. Rice disposal and consumption behaviour

In flood year, farmers in Kampong Thom averagely produced only 708 kg/ha of paddy but Pursat farmers were able to produce 1,408 kg/ha and wet season rice was merely production in both provinces. But the locations produced similar yields around 2,372 kg/ha in normal year. However, the disposal quantities were comparable between normal year and flood year in the areas. More than 60% was kept for home consumption in flood year. Farmer sold around 12% in flood year but 18% in normal year. Seed reserving quantity was also higher in flood year, 16% against 10% in normal year. Some 7% of the total households reduced consumed quantity because of food shortage during flood year. Only 23% could reserve rice for next year but over 50% bought rice in addition to the household produced for consumption and there was no change for the figures of stocked and purchased rice between flood and normal year.

A farm household need to buy additional rice of 147 kg in Kampong Thom and 212 kg in Pursat during flood year compared to 85 kg and 116 ka for normal year respectively. Because of flood, farmers could reserve as less as 12 kg per household in Kampong Thom and 60 kg in Pursat. Farmers were able to produce only 126 kg in Kampong Thom and 271 kg in Pursat as an average rice per capita production but the minimum requirement was 350 kg per capita therefore 224 kg and 79 kg were shortage in Kampong Thom and Pursat respectively as a result of flood. The numbers of households who live below the required rice per capita were as high as 88% and 71% in each site accordingly. Even average rice production per capita was 407 kg in Kampong Thom and 475 kg in Pursat in normal year, there were still 53% and 43% of total households in each location living below the required rice per capita.

Even though rice productions in both areas were severely affected by flood, famers would not reduce the numbers of meal per day. The majority nearly 80% had 3 meals and the rest had 2 meals and nobody had one meal a day. Very few households consumed less quantity or less food items caused by flood problem. But there were fairly large numbers up to 38% who reduced saving and also as many as 20% consumed the reserved seed for planting next season. A couple of cases deferred payment of loan during flood year. Though only 5% of farmers forced their children to drop school, that was severe case and it was not so common in the country.

2.15. Costs and returns of rice production

Gross returns of rice production between Kampong Thom and Pursat were fairly different that is USD 302 and 367 per hectare due to large gap yield because the price of rice was not different. There were two types of input costs, cash and non-cash, for rice production. The cash cost was comparable in the two areas but non-cash cost was largely different, around USD 227 in Kampong Thom and USD 337 in Pursat. Therefore, net returns above cash cost made no change that is bigger gross income produced bigger returns but net return above total cost caused farmers in Pursat greater loss though both locations made a negative total returns. For total cash input costs, seed, fertilizers, hired draught power and hired labour were closely shared, ranging from 18% to 27% in Kampong Thom. The four mentioned inputs were also predominant in Pursat but hired labour took up to 57% and 21% of hired draught power. There was also contrast for the share of non-cash input costs, own tractor and animal costing 34% and family labour 66% in Kampong Thom but the own tractor and animal requiring 57% and family labour 43% in Pursat. During flood year, overall gross returns of the two provinces reduced to USD 158 contributing to greatly negative net returns above total cost of USD -235.

2.16. Different income sources

Total household gross incomes of the two provinces were not so widely different, USD 1,455 in Kampong Thom and USD 1,578 in Pursat during normal year. The flood affected the former’s gross incomes by reducing around two thirds that of the normal year and around one third dropped for the latter’s. There were three main sources of total household annual incomes in flood year and the majority came from non-farm works followed by rice production and then sale of animals and products. In normal year, the three sources remained the biggest incomes but rice share increased and it was even the largest share in Kampong Thom. All incomes largely decreased in flood year regardless farm or non-farm one, except off-farm employment in Pursat dropped only 1%. Animal could be an additional income for farm households but flood badly affected the enterprise and cost 11% and 5% of extra incomes in each location. Since gross incomes were affected, net income was also hit accordingly but rice share dramatically dropped to -1% in Kampong Thom. Non-farm activities increased from 46% to 60% of the total net income shares.

Normally farmers in Kampong Thom and Pursat were able to earn USD 958 and USD 1,121 respectively of cash incomes from all sources per annum but flood occurrence severely depleted cash incomes to USD 370 and 734 for each province. Though rice was of major sources of gross and net incomes but it was minor cash income source, 1% in flood year and 5% in normal year because rice was mainly for home consumption. More interestingly, off farm employment shared up to 59% of Kampong Thom's cash income in flood year but it was only 2% in normal year though there was minor share and no change in Pursat. The share of sale other assets was only 1% for either gross income or net income but it was fairly large, 8% with regard to cash income. Similarly borrowing cash also increased its share.

2.17. Poverty and vulnerability

Annual net income per capita was USD 192 in Kampong Thom and 228 in Pursat which was considerably higher than the poverty line of USD 164 during the normal year but the farmers in Kampong Thom fell far below the poverty line in flood year with only USD 70 of net income and farmers' net income was USD 161 slightly fell below the line in Pursat. During flood year, the income was under the poverty line and mostly located in the 80% below poverty line distribution, 56% in Kampong Thom and 35% in Pursat. Net income of over 30% was distributed between poverty line to 80% below poverty line therefore only minority was allocated above poverty line. In contrast, around 22% stayed in the 80% above poverty line though more than 50% remained below poverty line in normal year.

2.18. Technology information sources

Accessibility and popularity of agricultural technology information sources were different between the two locations. Concerning rice cultivation information, majority of farmers in Kampong Thom preferred the source from other family members, TV or radio and NGOs but farmers in Pursat would depend on the source of printing materials such as newspapers and magazines and probably own experience. Kampong Thom farmers also mainly used the sources for soil nutrient management but there seemed no best source for Pursat besides neighbours or other farmers and own experience. The latter also preferred NGOs for animal husbandry information. TV or radio and NGOs were also reliable sources of such information as cultivation of non-rice crops, new rice varieties and rice pest control for Kampong Thom farmers meanwhile there was no specific sources reported by Pursat farmers.

2.19. Summary

Regardless different household numbers, population, land sizes and cultivated land area, land use, farming activities and varieties grown, typical key characters such as family labour, rainfed lowland rice, deep water rice, cultural practices, production cost, flood constraint and management practices within the twelve villages were quite homogenous. Though the practice of hired and exchanged labour were reported, family labour was very necessary for farming activities and most families could have 2 or 3 labours for all the villages. Rainfed lowland rice was the main rice production for the study sites even irrigation infrastructures such as canals were reported by some villages. Apart from rainfed paddy condition, every village covered the areas of deep water rice ecosystems but there was big variation among the villages according to their geographical locations. All villages were influenced by the same climate though there was slightly change of the two season duration and regular drought. Rainy season period was between May November and short dry period occurred in July and August. The cropping patterns in the villages were entirely based on rainfall because there was no irrigation source. Rice was the main crop and non-rice crops were additional cropping cultivated mainly on upper lands in dry season.

Concerning cultural practices in rice cultivation, transplanting was commonly carried out for rainfed lowland condition if there was no any constraint but direct seeding of dry seed on dry soil condition was always applied for deepwater rice. Seed rate was widely different for transplanting and direct seeding and the latter was even much higher than the former. Labour and land preparation costs were quite comparable among the villages and also the two provinces and the input costs seemed big increase over the last two years. Female labour's contribution to rice production activities from land preparation to post harvesting work was clearly designated, and the labour pattern was consistence among the villages whether that is family labour or other labour sources. Male took responsibility for more power required work such as land preparation, the application of fertilizers and chemical, field control, transport, and threshing while female carried out the rest of tasks including pulling, transplanting, harvesting until selling the grain. Regarding technology information, majority of farmers in Kampong Thom preferred the source from other villagers, TV/radio and NGOs but farmers in Pursat would depend on the source of printing materials such as newspapers and magazines and own experience.

All villages have experienced flood constraints though it would happen in different years and destruction level also varied from year to year. The villages suffered flood once a year in August with 2 metres depth was the most common cases but the flood duration was large variation between 15 and 60 days. However there was unlikely to have any method to overcome the flood problem. There was very small change in cultivated areas between normal and flood years in which overall cultivated areas but areas cultivated to modern rice variety were generally larger in flood year in Kampong Thom and Pursat. Rice varieties were not completely replaced by new ones because common varieties remain existing either flood or non-flood time. Rice yield was severely affected by the flood, losing 500 - 1,200 kg/ha. Modern variety was more favourable in the flood condition. Some common management practices to overcome flood problem were to shift the time for crop establishment, changing from transplanting to direct seeding, to increase seed rate and fertilizers, and to resow or replant. There seemed to be few cases reporting of increased and decreased labour as flood influence.

Rice disposal quantities were comparable between normal year and flood year in the areas though sold quantity was lower in flood year because of reserving greater for seed. Bigger amount of rice was bought in flood year to compensate yield loss as the production was below consumption requirement yet consumption behaviour was not changed that is three meals a day for the majority and some other with two meals. As great yield lost due to flood, the profit from rice would be zero or negative because rice production was only able to produce marginal returns. Therefore, farmers strongly depend on other income sources specially non-farm works provided over 50% of total incomes and also animal production which was also affected by flood. Annual net income per capita was considerably higher than the poverty line of USD 164 for normal year but the farmers in Kampong Thom fell far below the poverty line in flood year. The income was under the poverty line and mostly located in the 80% below poverty line distribution.

PART III. ADAPTIVE RESEARCH

3.1. Introduction

The IRRI-Japan Project has succeeded in introgressing of Sub 1 gene in to six mega varieties (Samba Mahsuri, Swarna, BR11, IR64, TDK1 and CR1009) which can be tolerated under submerged water up to 14 days and developed many breeding lines with Sub 1 gene. Dissemination of these Sub 1 varieties in farmer's fields in the Asian countries will maintain rice productivity especially when and where flooding occurs is immediate need of the project. These introgressive varieties are insensitive to photoperiod with early to intermediate maturing. The new rice lines shall be very useful for farmers who grow short growth duration varieties. On the other hand, since most of flood-prone rainfed lowlands of Cambodia are predominantly grown by the photoperiod sensitive varieties that flower during the period of mid October to mid November, the improvement of Cambodian popular rainfed lowland rice varieties for submergence tolerance would be very essential as well.

During the project the research activities were focused on (i) improvement for submergence tolerance of the most popular rice varieties released by CARDI (ii) testing for performance and adaptation of IRRI Sub1 varieties in the most flood-prone sites of Pursat and Kampong Thom, (iii) conducting farmer's participatory in selection and (iv) screening for submergence tolerance of CARDI's released varieties and local germplasm.

3.2. Improvement for submergence tolerance of the most popular rice varieties released by CARDI

Three popular of CARDI's varieties with different maturity duration (CAR6, Phka Rumduol, and Riang Chey) were crossed with IR64-Sub1 donor in 2008. Crossing between CAR6 and IR64-Sub1 were not succeeded due to different flowering time of CAR6 was later than IR64-Sub1 donor. Sixteen F1 seeds were produced from crossing between Phka Rumduol and IR64-Sub1 and twenty-two F1 seeds from crossing between Riang Chey and IR64-Sub1. All F1 seeds from each crossing were backcrossed with IR64-Sub1 as recurrent parent and harvested seeds were planted to produce BC1F1 plants. From BC1F1 plants were produced BC1F2 seeds. However, latter it was recognized that the team should used Phka Rumduol and Riang Chey as recurrent so crossing must be restarted and all BC1F2 seeds were stored in genebank.

Restarting crossing was began in January 2008 using Phka Rumduol, CAR6, Riang Chey, Phka Romeat and Phka Chan Sen Sar (a new released variety) as recurrent backcrossed with IR64-Sub1. BC1F1 seeds were produced and now backcrossed with recurrent parents to produce BC2F1 seeds. The BC2F1 seeds will be continuously generated for BC3F1 and so on using available financial source of the Breeding Program.

3.3. Testing for performance and adaptation of IRRI Sub1 varieties in the most flood-prone sites of Pursat and Kampong Thom

This activity composed of on-station trial and on-farm trial (OFAT).

3.3.1. On-Station trial: Screening for submergence tolerance

Pond size of 20 m width, 40 m long and 0.5 deep that was planned to establish at CARDI during April and May 2008 as submerged pond was not able to establish because of early and continuously rains. In May 2009, this pond was established but the water was too dirty. Thus, it could not be used to screen breeding lines during the project period.

Therefore in 2008, the team changed from pond screening to pot and tube screening. There were two sets of screening. First set (Set I) involved of 71 genotypes composed of 26 released varieties, 35 accessions of glutinous rice, eight varieties/breeding lines of Sub 1 and two local varieties (Table 4). All genotypes were sown on 18 July 2008 and then planted in PVC tubes with 30 cm high (with 20 cm depth soil) and 0.7 cm diameter. Each genotype was placed in three PVC tubes with two seedlings per tube. There were two submergence times with the first submergence was done for two tubes of each genotype started on 17 September and lasted for eight days in unclean water (see pictures 3-5). The second submergence time was done for the remaining tube of each genotype on 26 September in more clean water (Table 5). In clean water, plants were removed from water after seven days for 15 minutes to score and then re-submerged back for another three and seven days. Mean plant height including PVC tube at submerging was 72±8 cm and water depth ranged from 100 for seven days to 90 for 10 days treatment.

Table 4. Number of screened genotypes in different sources in Set I.

Released varieties	Glutinous accessions	Sub1-variety/line	Others	Total
26	35	8	2	71

Table 5. Sowing and submerged date, mean plant height (cm) and water depth (cm).

Description	Set I			Set II					
	7D	10D	14D	5D	7D	9D	11D	13D	15D
Sowing date		18-Jul				3-Dec			
Submerged date		26-Sep				25-Dec			
Mean plant height	72±8	72±8	72±8	41±6	42±4	48±4	47±4	48±4	50±5
Water depth	100	90	92	62					

Set II screening was designed as split-plot with submerged duration as main-plot and variety as subplot. The screening involved of 19 released varieties for medium and lower toposequence of rainfed lowland and IR64-Sub1 as check. Six submerged durations were imposed and they are 5 days, 7 days, 9 days, 11 days 13 days and 15 days. Each tube was repeated four times. Four to five seeds of each variety were sown on PVC tube as used for Set I screening. Thinning to two healthy seedlings was done at seven days after sowing. A small amount of compost was used to mix with soil to fill the tubes. Date of sowing and submerging, mean plant height and water depth at submerging are sown in Table 1.

In Set I, results indicated that there was no genotype survived after 8 day-unclean water treatment (Table 6). In clean water treatment, after 14 day-treatment, 16 genotypes survived with score 5, 20 with score 7 and the rest were completely death.

Table 6. Submergence score at different treatments and water conditions of Set I.

Submergence	Clean water			Unclean water
Score (1-9)	7D	10D	14D	8D
Score 3	26	16	0	0
Score 5	20	23	16	0
Score 7	13	19	20	0
Score 9	12	1	23	71
Total genotypes	71	59	59	71

Score 3: All leaves are alive, green but a bit soft, Score 5: >25% are death, some leaves re banded, Score 7: Most of leaves are death, Score 9: Plant is completely death.

In Set II, there were two genotypes (IR64-Sub1 and CAR 9) survived with score 5 at 15 day-treatment (Table 7). At 13 day-treatment, Phka Rumduol, Phka Rumdeng and CAR 4 also survived with score 5.5. However, all the tested genotypes survived at 7 day-treatment.

In 2009, two sets of genotypes have been conducted at CARDI (submerged condition and controlled condition) and at Kampong Thom (flood-prone area). A first genotype set composed of 36 genotypes (27 from IRRI and 9 are CARDI's released varieties) was conducted under submerged and controlled water conditions at CARDI (Tablev8). Seeds were sown on 8 August for both water conditions and transplanted on 4 September for controlled condition and on 8 September for submerged condition. Seeds of five genotypes (1, 4, 5, 12 and 15) badly germinated, therefore, only 31 genotypes were transplanted. A Randomized Complete Block Design with three replications was used and the plot size was 2 x 5 m.

For submerged condition, crop was imposed submergence for 15 days started from 9th to 25th October. Plant height of genotypes before submergence was measured and divided into five categories (≤50 cm; 20, 21, 22 and 23; 51-55 cm; 6, 7, 8, 10, 11, 16, 28 and 29; 56-59 cm; 2, 9, 13, 14, 17 and 26; 60-65 cm; 3, 18, 19, 24, 25, 27, 32, 33, 34 and 35; and 66-72 cm; 31 and 36). Water depth during imposing stress varied from 57 cm to 73 cm. Both water depth and genotype groups base on plant height are presented in Fig. 1. There was relationship between survived plants and plant height but also difference among the genotypes having plant height from 55 to 65 cm.

Experiment conducted at Kampong Thom involved 24 genotypes (20 from IRRI and 4 are CARDI's released varieties; Table 9). Seeds were sown on 6 July 2009 and transplanted on 23 July 2009. Crop was several times affected by different levels of flood (Fig. 2). First 5 day-flood affected crop growth at about 20 days after transplanting, second started from early September with water depth about 60 cm and the third was started from late September and lasted for about one month with water depth up to 128 cm. Thus, crop was seriously affected by long term flood mainly during flowering stage of most genotypes. After flood, most of genotypes recovered with producing new tillers and harvest was delayed until December.

Table 7. Submerged score and its standard deviation (SD) of tested genotypes at different treatments.

Variety	5 days		7 days		9 days		11 days		13 days		15 days		Mean	
	Score	SD	Score	SD	Score	SD	Score	SD	Score	SD	Score	SD	Score	SD
IR 64-Sub1	1.0	0.0	2.5	1.0	3.5	1.0	4.0	1.2	4.5	1.0	5.0	0.0	3.4	1.5
CAR 9	2.0	1.2	3.0	0.0	3.5	1.0	4.5	1.0	5.0	0.0	5.0	0.0	3.8	1.2
Phka Rumdoul	1.0	0.0	2.5	1.0	3.0	0.0	4.0	1.2	5.5	1.0	7.0	0.0	3.8	2.2
Phka Rumdeng	1.0	0.0	3.5	1.0	3.0	0.0	5.5	1.0	5.5	1.0	7.5	1.0	4.3	2.3
Riang Chey	2.5	1.0	3.0	0.0	4.0	1.2	5.5	1.0	7.0	0.0	7.5	1.0	4.9	2.1
CAR 4	3.0	0.0	4.5	1.0	5.0	0.0	4.5	1.0	5.5	1.0	7.5	1.0	5.0	1.5
Phka Romeat	2.5	1.0	5.0	0.0	5.0	0.0	6.0	1.2	7.0	0.0	7.5	1.0	5.5	1.8
Phka Rumchek	1.0	0.0	3.5	1.0	5.0	0.0	6.0	1.2	8.0	1.2	8.5	1.0	5.3	2.8
CAR 5	3.0	0.0	3.5	1.0	5.5	1.0	6.0	1.2	7.0	0.0	8.5	1.0	5.6	2.1
CAR 6	3.0	0.0	5.0	0.0	5.0	0.0	6.0	1.2	7.0	0.0	8.0	1.2	5.7	1.8
CAR 11	3.0	0.0	4.0	1.2	6.0	1.2	7.0	0.0	8.0	1.2	8.0	1.2	6.0	2.1
CAR 1	3.0	0.0	4.0	1.2	6.5	1.0	7.0	0.0	7.5	1.0	8.5	1.0	6.1	2.1
CAR 7	2.5	1.0	4.0	1.2	6.0	1.2	8.0	1.2	8.0	1.2	8.5	1.0	6.2	2.5
CAR 2	3.0	0.0	5.0	0.0	5.5	1.0	7.5	1.0	8.0	1.2	9.0	0.0	6.3	2.2
Phka Rumchang	2.5	1.0	5.0	0.0	6.0	1.2	7.0	0.0	8.5	1.0	9.0	0.0	6.3	2.4
CAR 12	4.0	1.2	4.0	1.2	7.0	0.0	7.5	1.0	7.5	1.0	8.5	1.0	6.4	1.9
Phka Chan Sen Sar	4.5	1.0	5.0	0.0	6.5	1.0	7.0	0.0	8.0	1.2	9.0	0.0	6.7	1.7
CAR 3	3.0	0.0	5.5	1.0	7.0	0.0	7.5	1.0	9.0	0.0	9.0	0.0	6.8	2.3
CAR 8	4.0	1.2	5.0	0.0	7.0	0.0	8.0	1.2	9.0	0.0	9.0	0.0	7.0	2.1
CAR 13	5.0	0.0	5.5	1.0	6.5	1.0	7.5	1.0	8.5	1.0	9.0	0.0	7.0	1.6

Table 8. Percentage of survived plants under submerged condition (%SPSC) and grain yield under controlled condition (GYCC) at CARDI, wet season 2009.

No	Genotype	%SPSC	GYCC (t/ha)
1	IR 07F102 (IR64-Sub1) (BC2F3)		
2	IR 05F102 (Swarna-Sub1) (BC3F3)	0	3.94
3	IR 07F287(Samba Mahsuri-Sub1) (BC3F3)	0	2.53
4	IR 07F289 (TDK1-Sub1)		
5	IR 07F290 (BR11-Sub1)		
6	IR 64	0	2.27
7	Swarna	0	3.74
8	Samba Mahsuri	0	3.06
9	IR 43069-UBN 507-3-1-2-2	3	3.39
10	CR 1009	1	4.35
11	BR 11	0	3.72
12	IR 57514-PMI 5-B-1-2		
13	IR 82355-5-2-3	1	1.55

14	PSB Rc 68	0	2.85
15	TDK 1 (Glutinous)		
16	IR 07F291 (CR1009-Sub1)	0	4.37
17	IR 70181-32-PMI-1-1-5-1	0	2.44
18	IR 70213-10-CPA-4-2-3-2	4	2.50
19	IR 70213-9-CPA-12-UBN-2-1-3-1	3	2.42
20	IR 64-Sub 1 (IR 07F102)	0	1.99
21	Swarna-Sub1 (IR 05F102)	0	3.43
22	Samba Mahsuri-Sub1 (IR 07F287)	0	2.04
23	BR 11-Sub1 (IR 07F290)	0	3.10
24	IR 70173-49-SRN-9-UBN-5-B-1-2	12	2.98
25	IR 70215-40-CPA-1-3-B-1	4	3.81
26	IR 70224-1-7-1-1-1-1	0	2.90
27	IR 70174-14-SRN-4-UBN-2-B-1-2	8	3.27
28	IR 66	0	3.01
29	Sen Pidoa	0	3.15
30	Phka Rumduol	9	2.39
31	Phka Romeat	13	2.55
32	Phka Chan Sen Sar	6	2.82
33	CAR 4	10	3.62
34	CAR 6	7	3.63
35	CAR 9	8	3.89
36	Riang Chey	11	4.10

Significant level of ANAVA for grain yield under controlled condition (YCC): 0.66**

Shading indicates genotypes that seeds are not germinated.

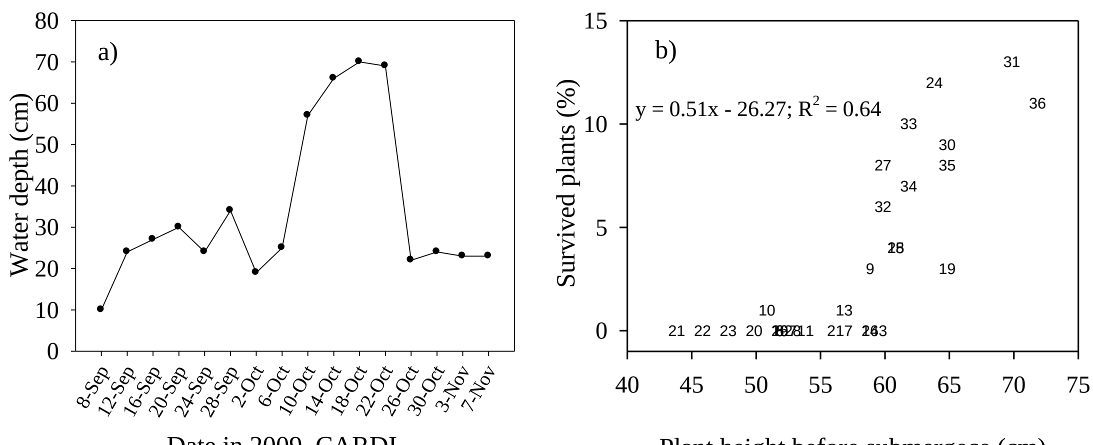

Fig. 1. Water depth (a) and relationship between survived plants and plant height (b).

Table 9. Plant height (PH, cm), survival plant (SP, %) and grain yield (GY, t/ha) of tested genotypes in Kampong Thom, wet season 2009.

No	Genotype	PH	SP	GY
1	IR 05F101 (Swarna-Sub1) (BC2F3)	63	45	1.17
2	IR 07F102 (IR64-Sub1) (BC2F3)	97	25	1.47
3	IR 07F286 (IR64-Sub1) (BC3F3)	93	30	2.19
4	IR 05F102 (Swarna-Sub1)	116	48	2.53
5	IR 07F101 (Samba Mahsuri-Sub1) (BC2F3)	112	65	1.65
6	IR 07F287 (Samba-Mahsuri-Sub1) (BC3F3)	103	45	1.52
7	IR 07F289 (TDK1-Sub1)	103	68	2.44
8	IR 07F290 (BR11-Sub1)	77	47	2.48
9	IR 51514-PMI-5-B-1-2	113	75	2.47
10	IR 054199	63	12	0.64
11	IR 05A193	60	5	0.61
12	IRRI 119	109	72	2.64
13	IR 64-Sub1(IR 07F102)	63	25	1.12
14	Swarna-Sub1 (IR 05F102)	120	68	2.00
15	Samba-Mashuri-Sub1 (IR 07F287)	110	70	1.71
16	BR11-Sub1 (IR 07F290)	116	48	2.07
17	IR 70174-14-SRN-4-UBN-2-B-1-2	43	3	0.15
18	IR 70173-49-SRN-9-UBN-5-B-1-2	40	3	0.27
19	IR 70224-1-7-1-1-1-1	103	23	0.75
20	IR 70215-40-CPA-1-3-B-1	83	5	0.33
21	Phka Rumduol	86	68	2.33
22	Phka Romeat	120	68	2.45
23	CAR 9	27	17	0.80
24	Riang Chey	113	53	2.33
Mean		89	41	1.59

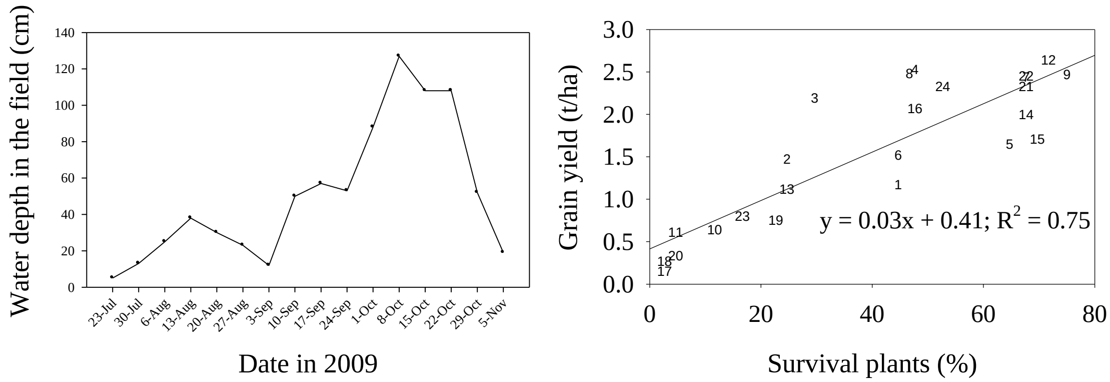

Fig. 2. Water depth level and relationship between grain yield and survival plants.

Average over replications indicate that genotypes differentiate in grain yield although most of them have recovered after flood and yielded from 0.33 t/ha to 2.69 t/ha with average of 1.59 t/ha. Grain yield of genotypes positively related with number of survival plants ($P<0.01$) as indicates in Fig. 2. Genotypes 12, 9, 22, 24 and 24 yielded higher as they survived more, while genotypes 4, 8, 24 and 16 produced also high yield with around 50% survival plant. In contrast, genotype 3 produced relatively high yield but with about 1/3 remaining plants. Number of survival plants is also positively associated with the plant height ($y=0.68x - 19.4$, $R^2=0.57$*).

3.3.2. On-Farm Trial: Testing for performance and adaptation of IRRI Sub1 varieties in the most flood-prone sites of Pursat and Kampong Thom

We planned to conduct 40 sets of on-farm adaptive trial (OFAT) in both provinces, 20 each. However, base on the available seeds and farmer co-operators, we were able to conduct only 16 sets (two failed) in Kampong Thom and 10 sets (3 failed) in Pursat. At each site, three Sub1 varieties were tested along with the farmer's variety. Each variety transplanted in 5 x 20m plot with 0.5m spacing between plots. The trial was managed by farmers, but they need to record date of sowing and planting, plant height and grain yield at harvest, water depth at transplanting, 15 and 30 days after transplanting, date and water depth at the beginning of flood (identified by farmers), 3, 6, 9, 12 and 15 days after flooding.

Base on the water depth at different stages of crop, we group water level into five groups as indicate in Fig. 3. At transplanting, water depth of all water level groups varied from 11-17 cm and at 15 days after transplanting water level of group 1, 3 and 4 was around 20 cm except group 2 was 28 cm. Water level group 1 was 27 cm depth at the beginning of flooding and then increased up to 67 cm after nine days and a bit receded to 63 cm at 15 days after flooding. Water depth at group 2 increased immediately after transplanting up to 39 cm at the beginning of flooding and 42 cm at three days after then it was consistent up to 15 after flooding. There was similar trend for group 3 with a maximum water depth of 38 cm at nine days after flooding. There was no flood for water level group 4, except dry period for about a month during reproductive phase of tested varieties. There were three sets of OFAT involved in group1, five in group 2, nine in group 3 and four in group 4. Number of tested varieties in each water level group is given in parenthesis in Table 6.

Grain yield obtained from OFAT is presented in Table 10. In general, mean grain yield of farmer's varieties was higher than the tested varieties. Samba Mahsuri-Sub1 and Swarna-Sub1 were completely failed and IR64-Sub1 yield 0.33 t/ha under water level group 1 while farmer's varieties produced 1.63 t/ha. In water level group 2 while water depth rose up to more than 40 cm immediately after transplanting, all tested varieties yielded 0.54 (BR11-Sub1) to 0.68 (Swarna-Sub1) time of farmer's varieties. In water level group 3 and 4, all tested varieties yielded a bit lower than the farmer's varieties, except IR64-Sub1 in water level group 3 yielded 0.61 times of farmer's varieties.

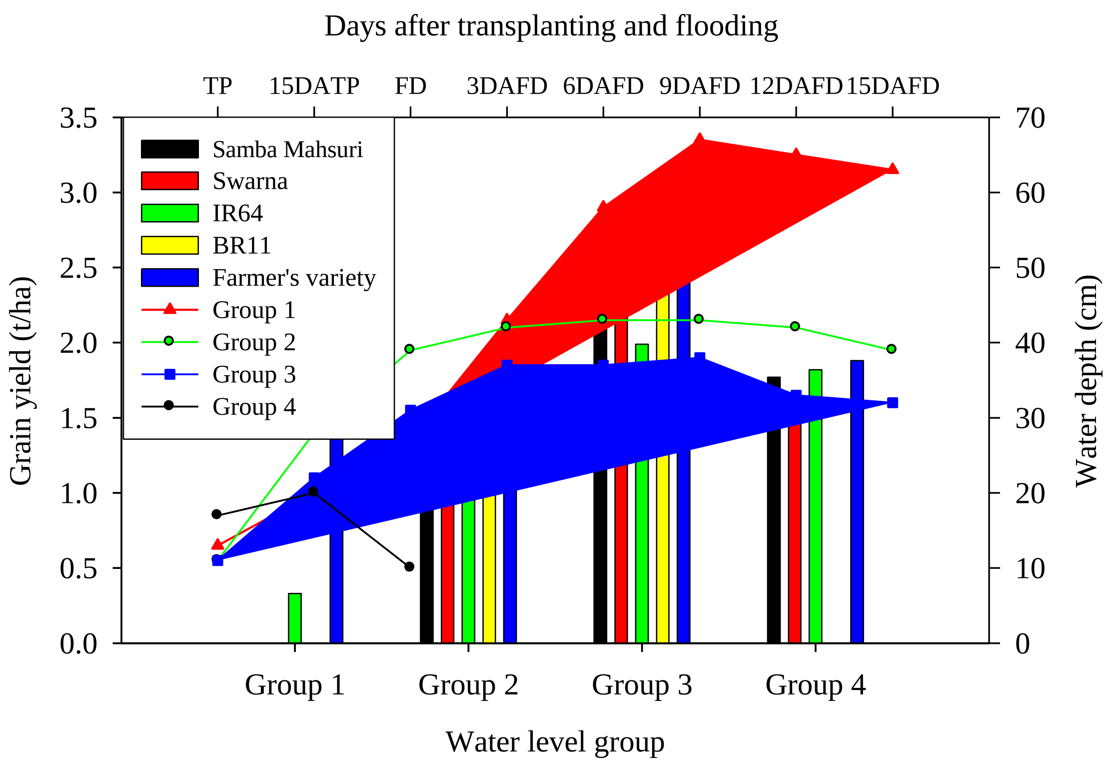

Fig. 3. Performance of water level groups and grain yield of tested genotypes.

Table 10. Mean grain yield at four water level groups and overall mean.

Water level	Samba Mahsuri-Sub1	Swarna-Sub1	IR64-Sub1	BR11-Sub1	Farmer's
Group 1	0.00 (3)	0.00 (3)	0.33 (3)		1.63 (3)
Group 2	1.34 (5)	1.39 (5)	1.23 (2)	1.10 (2)	2.04 (5)
Group 3	2.83 (9)	2.91 (9)	1.99 (5)	3.00 (3)	3.24 (9)
Group 4	1.77 (4)	1.60 (4)	1.82 (4)		1.88 (4)
Mean±SD	1.87±1.20	1.88±1.21	1.48±0.92	2.24±1.14	2.47±0.89
Farmer's variety:	Phka Rumduol = 14		Riang Chey = CAR6 = 2		Others = 3

Number in parenthesis indicates number of sites.

3.4. Farmer preference analysis – farmer field day activities

3.4.1. Introduction

The project of “Dissemination of submergence-tolerant rice varieties and associated new production strategies” is to introduce varieties are able to cope with flush flood condition. The crops are able to recover and well perform after submerge for not more than two weeks. This favourable characteristic is useful for farmers who cultivate rice with the risk of this constraint. Farmers who grew rice under this condition would be keen to have this tolerant variety. According to the baseline survey, the varieties would be suitable for farmers in Kampong Thom and Pursat provinces. However, successful performance of the varieties on farm condition and target flood prone areas is important. Further, preference which leads to eventually adoption from the growers is even more important. A feedback from farmers would be critical for the new technology introduction especially new varieties because the technology will be used by the farmers and influence their household economic condition in the long run. Varieties may be satisfied the breeders and researchers but may not always be necessary to farmer. Therefore, an evaluation from farmers, potentially adopters would be important. The varieties are useful when they are suitable for farmers' condition and accepted by the farmers. The trials are conducted in Kampong Thom and Pursat provinces but we were able to organize the field day only in Kampong Thom because of inconvenience timing and field situation in Pursat.

There are different approaches to have farmers' opinions and farmer field day is one of good participatory tools. We conducted famer field day to obtain farmers' assessment over the genotypes in on-farm trial condition, 2008 and in replicated trial, 2009 in Kampong Thom. However this initial evaluation focused on rice plant performance and grain producing under the stress condition rather than cook rice quality.

When all participants were gather at the field site, we clearly explained them about the purpose of the event with a clear explanation of evaluation process and also information of the varieties and field experiment. Individual farmer was given with a positive ballot and a negative ballot for presenting their decision. At each experiment plot, we put a stick with an envelope for the farmers to cast their ballots. We asked all farmers to carefully observe each variety not only grain and panicles but also other characters by walking around the plots before making their important decision. The analysis of preference score was expressed as:

$$\text{Preference score} = \frac{\text{number of positive votes} - \text{number of negative votes}}{\text{total number of positive and negative votes}}$$

3.4.2. Results of assessment and discussions

Pren village, 2008: with facility from provincial field collaborators who were responsible for the on farm experiment of the project, there were two farmer field days conducted in Stoeung Sen district of Kampong Thom province. One of 8 field trials in Pren village was designated for the farmer participatory evaluation. There were 39 farmers participating the field day although we invited only 30 farmers. The reason for over voluntarily participants was that the field location was just located inside the village so farmers could easily reach the field and the event also attracts the farmers. Further, the favourable weather, cool wind and mild sun heat was also encouragement and the majority farmers were available after harvesting. Concerning gender proportion, it was predominant of female participant with 67% of the total numbers. There were only three submergence tolerant varieties (Samba, Swarna and IR64) plus farmer's Phka Rumduol as check variety.

The result of the votes present that Phka Rumduol was the most popular among the four varieties with preference score of 0.41 but all other varieties received negative preference score in which negative votes were greatly larger than positive ones (Table 11). Apart from Phka rumdoul variety, regardless negative preference score, Swarna received at least 5 positive ballots while IR64 got 1 ballot and non for Samba. But IR64 and Swarna obtained most negative votes though they were in lead for positive votes and the former has minor negative votes. The farmers did not give many reasons for accepting Phka Rumduol and decline other varieties but they defend that this variety was good eating quality and high market demand with high price.

A gender analysis for the preference indicates that 24 female participants of 26 female positive votes, accounting for 92%, selected Phka Rumduol but 1 of the 26 negatives voted rejects this variety. The male group shared larger percentage of preference to Swarna and IR64, up to 31% and 69% for Phka Rumduol but there was no male declining Phka rumdoul variety.

Another interesting result, without Phka Rumduol variety, Samba was the most popular (17 females and 12 males) followed by Swarna (1 male and 7 females) and IR64 last. The opinions were the result of farmer's response by raising their hands during the discussion after presenting the result of votes. So this result seemed that the most Phka Rumduol growers would choose Samba if the former was not available.

Table 11. Preference score in Pren village

Variety	Female (n=26)		Male (n=13)		Total (n=39)		Preference score
	+	-	+	-	+	-	
Samba-Sub1	0	3	0	1	0	4	(0.051)
Swarna-Sub1	2	6	3	10	5	16	(0.141)
IR64-Sub1	0	16	1	2	1	18	(0.217)
Phka Rumduol	24	1	9	0	33	1	0.410
Total	26	26	13	13	39	39	78

Krachab village, 2008: in Archa Leak commune, Stoeung Sen district where the second farmer field day was carried out to test the preference of the varieties. The same process of participatory assessment was applied in this location. Samba, Swarna and IR64 were trialed to compare farmer's variety named Neang Harm but unfortunately IR64 was harvested due to early maturity. Different from previous location, there was only 19 farmers participating the field day. Though number of female was fewer than male, it was up to 37% hence the proportion between male and female would be pretty well represented. The experimental plots remained very wet so the condition was not favourable for farmers to walk across the plots to observe but they were able to clearly observe from paddy bunds due to closed distant between the bunds and crops.

More farmers voted for Swarna along with a couple of negative votes and the preference score was 0.184 compared to negative points of other two varieties (Table 12). The preference of Samba and farmer's variety was very closed, 4 and 5 votes respectively and the rejection was also comparable for the two varieties, some 7 and 9 negatives for

Samba, Neang Harm respectively. There was no declining from female for Swarna but 3 males did not accept the variety. There was no significantly different between female and male for other two varieties. Long panicle and more grain per panicle were reasons to select the varieties.

Table 12. Preference score in Krarchab village, Archa Leak commune

Variety	Female (n=7)		Male (n=12)		Total (19)		Preference score
	+	-	+	-	+	-	
Samba	2	3	2	4	4	7	(0.078)
Swarna	3	0	7	3	10	3	0.184
Neang Harm	2	4	3	5	5	9	(0.105)
IR64*	-	-	-	-	-	-	-
Total	7	7	12	12	19	19	38

*IR64 was harvested before the farmer field day.

Before harvest, a total of 23 farmers were invited to visit the experiment and requested to evaluate the best performance of genotype that they prefer. Ten outstanding genotypes (4, 7-9, 12, 14, 16, 21, 22 and 24) were selected for farmer's judgment. Among the evaluated genotypes, five have been selected by different number of farmers (10 farmers selected genotype number 9, six selected number 6, three selected number 21, two selected number 12 and 21).

Replicated trial, 2009: A replicated trial involving 24 tested genotypes was used for farmer preference analysis. A total of 23 farmers were invited to evaluate 10 selected genotypes base on performance remaining after flood (Table 13).

Table 13. Preference score in replicated trial, Kampong Thom, 2009.

No	Genotype	Positive vote	Negative vote	Preference score
9	IR 51514-PMI-5-B-1-2	10	13	(0.1)
8	IR 07F290 (BR11-Sub1)	6	17	(0.5)
21	Phka Rumduol	3	20	(0.7)
12	IRRI 119	2	21	(0.8)
24	Riang Chey	2	21	(0.8)
4	IR 05F102 (Swarna-Sub1)	0	23	(1.0)
7	IR 07F289(TDK1-Sub1)	0	23	(1.0)
14	Swarna-Sub1(IR 05F102)	0	23	(1.0)
16	BR11-Sub1(IR 07F290)	0	23	(1.0)
22	Phka Romeat	0	23	(1.0)

3.4.3. Conclusion

A certain points are required to be considered which may directly or indirectly influence this assessment result of preference analysis. We need to well understand the condition of the experiments. The duration and condition of flood (water depth) occurred at the trial plots was skeptical though it was reported flooding by field coordinators because all varieties still grow quite well compared to other experiments in the same village were suffered flood and almost no yield. Though we did not weight the yield sampling but we could visually assess the crop situation. So it was likely that the trials designating for the field day experienced less constraints such as short period (only few days) and shallow flood (rice not submerged). We need to clarify with field collaborators and involved people about the field condition during the trial period, concerning water level and also other factors.

Even though name of each variety was not told, it would not be difficult for farmer to identify the variety like Phka Rumduol though the new varieties may be known. Therefore the dominant selection of Phka Rumduol would not be surprised because farmers have known this variety very well, due good eating quality and high market demand and price. Further, there was no evident that the new varieties were more tolerant to submergence/flood because all experiment plots grew well. Farmers also indicate that Phka Rumduol was very tolerant to flood. Therefore, farmers did not simply select unfamiliar varieties with no typical characters.

Single character such submergence tolerant alone may not strong enough to encourage farmers to adopt the varieties if option is not limited for farmers, that is field condition is absolutely flood every year. As mentioned, new technology is not always necessary if it is not introduced in the appropriate area and time especially the degree of requirement from farmers for the new technologies.

PART IV. SEED SYSTEMS AND DISTRIBUTION

Table 14 indicates area and harvested seeds that were increased. First seed increase of four varieties (IR64-Sub1, Awarna-Sub1, Samba Mahsuri-Sub1 and BR11-Sub1) conducted in late wet season 2007 was harvested in early February 2008. A maximum of 10 kg of seeds of each variety was harvested, because crops were seriously damaged by bird in the late ripening stage. All harvested seeds were sown on 22nd February 2008 to increase for 40 sets of on-farm trial going to conduct in Kampong Thom and Pursat in this wet season. Transplanting was done at 30 days after sowing with plot size of 1100 m2 for IR64-Sub1, 800 m2 for Swarna-Sub1, 940 m2 for Samba Mahsuri –Sub1 and 1120 m2 for BR11-Sub1.

There was BPH outbreak started on 25th March and three days later crop was sprayed with Bassa (50g/18l) and Bultyl (35 m.l/18l) (recommended by plant protection team). The treatment was succeeded and there was a few BPH observing after a week of spraying. BPH caused hopperburn more seriously for IR64-Sub1 and Samba-Mahsuri-Sub1 than the other two varieties. BPH also infected virus causes grassy stunt (see pictures). Plant protection team estimated incidence of grassy stunt of 30% for Samba-Mahsuri-Sub1, 28% for IR64-Sub1, 11% for Swarna-Sub1 and 5% for BR11-Sub1. Grassy stunt plants were removed from the field and burned.

At milking stage, as the crop was alone at CARDI field, bird seriously damaged the seeds resulting small amount of seeds remaining for OFAT and the 3rd increase. Seeds of the 3rd

increase were sown on 16th June 2008 and transplanted 33 day-old seedlings on around 1100 m2 each variety. All harvested seeds were kept for further use.

Table 14. Date of sowing (SD), transplanting date (TD), area (m^2) and harvested seeds (kg) of three seed increases for four Sub 1 varieties at CARDI.

Variety	SD:17Jun	TD:15Jul	SD:22Feb	TD:24Mar	SD:16Jun	TD:19Jul
	Area	Harvest	Area	Harvest	Area	Harvest
IR64	100	5	1100	8	1032	271
Samba Mahsuri	100	13	940	11	1128	223
Swarna	100	11	800	39	1140	441
BR11	100	6	1120	3.5	1128	394
Total	400	35	3960	61.5	4428	1329

Pictures: Seed increase damaged by Stem Borer and Brown Plant Hopper

PART V. CAPACITY BUILDING AND INFORMATION DISSEMINATION

1. Plant Breeding Course: Laying the foundation for the 2nd green revolution from 1-12 October 2007: Mr CHOU Vichet
2. MAS for submergence tolerant rice held at IRRI, Philippines from 21-25 January, 2008: Mrs SAKHAN Sophany
3. Data management and analysis training-workshop for the socioeconomic component held on 8-9 April 2008 in Bureau of Rice Research and Development Rice department, Bangkok, Thailand: Mr CHEA Sareth.
4.Participatory Approach to Up Scaling the Adoption of Submergence Tolerant Rice" held at IRRI from 14-25 April 2008: Mr Nou Kihen (CARDI), Mr Thiv Sithan (Pursat) and Than Vanthy (Kampong Thom)
5. Introduction of GIS, 27-30 Jan 09, CARDI: Mr TOUCH Veasna and Mr LIM Vandy

ACKNOWLEDGEMENTS

Financial support from the Japan-ADB is gratefully acknowledged. We thank to IRRI and mainly CURE's Team for technical support and leadership of the project.

REFERENCES

Chaudhary, R.C. and Papademetriou, M.K. 1999. Perspectives of rice production in Asia Pacific under the current economic and regulatory upheaval. Cambodian Journal of Agriculture, 2, 1–14.

Javier, L.E, Men Sarom, Pith, K.H., Khun, L.H., Say, P., Sin, S., Ouk, Makara, Hun, Y., Suy, S., Thun, V., Sidhu, G.S., Mishra, D.P., Sahai, V.N., Chaudhary, R.C. and Ledesma, D.R., (1999). Rice germplasm catalog of Cambodia III.

MAFF, 1996. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 1995-1996 and planning for 1996-1997. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 1997. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 1996-1997 and planning for 1997-1998. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 1998. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 1997-1998 and planning for 1998-1999. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 1999. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 1998-1999 and planning for 1999-2000. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2000. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 1999-2000 and planning for 2000-2001. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2001. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 2000-2001 and planning for 2001-2002. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2002. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 2001-2002 and planning for 2002-2003. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2003. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 2002-2003 and planning for 2003-2004. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2004. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 2003-2004 and planning for 2004-2005. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2005. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 2004-2005 and planning for 2005-2006. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

MAFF, 2006. Report on activities of Agriculture, Forestry and Fisheries. Workshop on National achievement in 2005-2006 and planning for 2006-2007. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia (In Khmer).

Men Sarom, Ouk Makara, Hun, Y., Sakhan, S. and Pith, K.H. (2001). Rice-breeding methods for Cambodia. In: Fukai, S. and Basnayake, J., eds. Increased Rainfed Lowland Rice Production in the Mekong Region. Proceedings of an International Workshop, Vientiane, Laos, 30 Oct-2 Nov, 2000. ACIAR Proceedings, 101, 236-244.

Ouk Makara., Chaudhary, R.C. and Javier, E.L. (1995). Conventional and innovative strategy of rice breeding for rainfed lowlands of Cambodia. In: International Rice Research Institute, ed. Fragile Lives in Fragile Ecosystems. Proceeding of the International Rice Research Conference, 13-17 Feb 1995. P.O. Box 933, Manila, Philippines. 976 p., 855–864.

Ouk Makara, Men Sarom and Nesbitt, J.H. (2001). Rice production systems in Cambodia. In: Fukai, S. and Basnayake, J., eds. Increased Rainfed Lowland Rice Production in the Mekong Region. Proceedings of an International Workshop, Vientiane, Loas, 30 Oct-2 Nov, 2000. ACIAR Proceedings, 101, 43-52.

Sahai, V.N., Chaudhary, R.C. and Sin, S. (1992a). Rice Germplasm Catalog of Cambodia I. Cambodia-IRRI-Australia Project. P.O. Box 01, Phnom Penh, Cambodia.

Sahai, V.N., Chaudhary, R.C. and Sin, S. (1992b). Rice Germplasm Catalog of Cambodia II. Cambodia-IRRI-Australia Project. P.O. Box 01, Phnom Penh, Cambodia.

FINANCIAL REPORT

Total Fund Received:	40,621.96
Expenditure	
Personnel:	13,208.00
Supplies and Services:	17,803.52
Travel and Subsistence:	9,610.44
Balance:	0.00