Philippine Rice R&D Highlights 2013

COPING WITH CLIMATE CHANGE PROGRAM

TABLE OF CONTENTS

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Program Leader: RFOrge

Executive Summary

Climate Change (CC) has been considered as the most serious and most pervasive threat facing humanity today. Its impact in the Philippines is becoming more apparent and devastating. Climate-related natural disasters, such as drought, floods, and storms, are the principal sources of risk and uncertainty in the agriculture sector nowadays. Since 34 percent of the country's labor force is involved in agriculture, the livelihood of a large share of the population is at risk due to CC.

Rice is one of the crops that is highly affected by CC. Several studies showed that rice growth and production are affected by extreme weather events such as higher minimum temperature (Peng et al. 2004; Auffhammer et al. 2006; Centeno and Wassmann 2010), and lower solar radiation (Peng et al. 2004) which ultimately results to low yields. In addition, flood and drought can cause reduction in area harvested to rice. Since rice is an important commodity in the country, being the most frequently eaten staple food of the Filipinos, it is just proper that researches be conducted toward making the rice-based rice farming systems resilient to climate change.

In general, this Program aims to contribute to the national goal of attaining and sustaining rice self-sufficiency in the country by developing climate-resilient rice-based farming systems. In particular, it aims to:

1. Generate new knowledge and information related to CC so that science researchers can formulate sound research interventions toward helping the farmers adapt to CC;
2. Develop adaptation technologies/strategies for rice farming in order to minimize possible crop production losses caused by CC; and
3. Develop systems of diversifying the household sources of food and income to further enhance CC adaptive capacities of rice farming communities.

I. Generation and Management of Local Knowledge and Information on Climate Change

Project Leader: JG Tallada

Inevitably, the general climatic patterns are bound to change as a result of unhampered accumulation of greenhouse gases in the atmosphere that were brought by incessant economic industrialization, and intensification of agriculture. The demand for an even greater amount of food will also exponentially increase because of rapid increase of population. Thus, this will increase the pressures to safeguard our food security.

Because of the miniscule total land area and population, the Philippines will hardly be going to contribute significantly to the detriment of the climate. However, the country is in the forefront of bearing whatever the brunt of the ill effects of climate change owing to its geographical location. Recent experiences of weather extremes, such as intensified typhoons and increased frequency of flooding, and the lenghtening episodes of El Niño, are evidences of events that place the country in a very precarious position.

We may not be able to mitigate climate change but we can contribute to the understanding of its underpinning dynamics especially on how it will impact our currently vulnerable food security. At the cornerstone of this is ensuring the availability of reliable and quality weather data.

The main goal of this project is to generate and manage local climate-related information and technologies in support to the climate change research. Specifically, this project aims to:

1. Organize, systematize and manage the current weather stations of the institute;
2. Collate, verify, summarize, store and deliver the daily weather and general climatic data they gather;
3. Develop, test and deploy locally-assembled sensors and instrument systems integrated into automatic weather stations;
4. Understand the impacts of climate change on crop production, pest and disease dynamics;
5. Collaborate with other institutions that are involved with climate change research.

Enhancing PhilRice agrometeorological monitoring capability and upgrading of facilities

JG Tallada, PE Mabalot, JP Jimenez, JL de Dios, AC Arocena, and EJP Quilang

To augment the demand for more crop field monitoring facility that can capture effectively the crop-environment information with a high degree of accuracy, and in a timely and cost-effective way, the Advanced Science and Technology Institute (ASTI) of the Department of Science and Technology (DOST), in collaboration with the Philippine Rice Research Institute (PhilRice), and with the funding support from the Grants-In-Aid Program of DOST, was able to develop a state-of-the-art field monitoring system for agro-meteorological monitoring. Eight (8) sets of Field Monitoring Stations (FMON) were deployed in December, 2012 at PhilRice research stations in Ilocos Norte, Isabela, Albay, and Nueva Ecija.

However, the FMONs installed were not functional due to the problems encountered with the data transmission through WiFi. Thus, series of meetings between ASTI and PhilRice were conducted to have the weather stations to be up and running by last quarter of 2013 and at the same time to facilitate the proper termination of the project. This was done by shifting the mode of data transmission of FMON units from WiFi to GSM. The ASTI provided GSM modules without additional expenses from PhilRice.

Furthermore, concerns such as securing an instrument manual that will cover the operation, maintenance, and basic troubleshooting of the FMON units and to have standard units for weather parameters were also addressed with ASTI assuring PhilRice to provide the aforementioned needs.

Highlights:

- An "Enhancement of PhilRice Agrometeorological Monitoring Capability Seminar and Planning Workshop" was conducted on August 19-20, 2013, to gather all the people in charge of the weather stations in the PhilRice system. Its main objectives were to: a) re-orient Agromet staff on basic agromet station operations and processes; b) evaluate the effectiveness and efficiency of the implementation of Field Monitoring System; and c) discuss other agromet-related issues and concerns. During the seminar and planning workshop, the components and maintenance of the Automatic Weather Stations, FMONs, as well as the weather instruments wherein data were manually gathered, were discussed, giving emphasis on maintenance to ensure accuracy of data gathered. Issues and concerns from each branch stations were also tackled, namely: 1) technical operations/procedures especially on the upkeep of weather instruments; 2) budgetary requirements for the maintenance of the agromet stations; 3) focal persons in each branch stations; 4) training needs; and 5) the strategies to maximize the use of data generated from the Agromet Stations.

- A meeting was held at ASTI on December, 2013 to discuss the critical steps to make the whole FMON system operational again. Below were the timelines set by PhilRice and ASTI on the planned activities.

Activity	Timeline	Agency Responsible
1) Modification of FMON communication	December 2013	ASTI
2) Training and installation of the modified FMON system	January 2014	PhilRice/ASTI
3) Operation of the system for four weeks	February 2014	PhilRice
4) Meeting conference for final evaluation	March 2014	PhilRice/ASTI

- One of the objectives of the project is to develop a database and be made accessible to researchers. However, there are primary steps that needs to be done and are already on the process of being done, namely:, 1) establishment of the Agromet metadata for each branch station; 2) centralizing the processing of weather data; and 3) addressing the problems on different data formats.

II. Development of crop management strategies and decision support systems for climate change adaptation
Project Leader: AOV Capistrano

In agriculture, particularly for rice production, adaptation may come in different forms but may be specific for addressing a particular impact. There are in actuality four known climate change impacts that create uncertainty in agriculture, which are flooding, droughts, salinity intrusion, and extreme temperature. Coping with these impacts include, among other things, cropping management technologies or adaptive strategies, decision support tools for various crop managements and policy recommendations for the institutionalization of adaptive strategies. With the onset of climate change impacts in the country, the importance of adaptation in rice production cannot be emphasized more than ever. The onslaught of typhoons, subsequent droughts are just a preview of what the country can experience in the coming years. It is, therefore, imperative that a plan of action be put in place at the soonest possible time. Research and development initiatives must put all theories into practice to optimize technology potentials and equip the agriculture sector to minimize the effect of climate change impacts on food production.

This project aims to develop new and innovative crop management technologies, strategies, and decision support tools for rice production to cope with the impacts of climate change.

Specifically, it aims to:

1. evaluate the potential of various crop management strategies/ options for stabilizing rice yields amidst climate change impacts;

2. evaluate new and innovative technologies with the potential of reducing the impacts of climate change to rice production;

3. develop and evaluate decision support tools and equipment that will empower farmers and technicians to make informed decisions and avert risks in rice production due to climate change; and

4. provide support information for policy recommendations that will institutionalize adaptive strategies having the potential to reduce or cope with the impacts of climate change in rice production.

Improved rice–azolla farming systems for submergence-prone areas
GA Nemeño and DLG Escañan

Many experiments have demonstrated the effectiveness of Azolla as a biofertilizer on rice, although the extent of the benefit varies greatly according to climate, method of application, the species of Azolla used, and many other factors, but Sisworo et al. (1990) found that Azolla was equally effective as urea on rice when both were applied at the rate of 30 kg N ha-1 at transplanting and maximum tillering stage.

Thus, this study was conducted to examine the impacts of improved rice-Azolla farming systems technology through the improvement in transplanting pattern, tillage, and nutrient management in the submergence-prone areas. Specifically, the study aims to (a) determine the influence of transplanting pattern in increasing plant population per square meter and in sustaining rice yields in submergence-prone areas; (b) evaluate the efficiency of different Azolla application as alternative source of N in rice areas vulnerable to climate change; (c) evaluate the effects of reduced tillage on the N efficiency, yield and yield components of the plant applied with Azolla in prolonged submergence areas; and (d) assess the sustainability and practicability of improved rice-Azolla farming systems technology in climate change vulnerable areas.

Highlights:

- Established evaluation study on increasing population density through the different planting patterns: square (20x20cm, 12x12cm), rectangular (15x25cm), triangular/ hexagonal (10-12cm), and twin zigzag (10x10cm) pattern.

- Results of the study revealed that increasing the population density per square meter by planting the crop at twin zigzag planting pattern showed the highest yield with 5.42 t ha-1 while the lowest was obtained in plots planted in square pattern at 20x20 cm with only 3.68 t ha-1. High yield obtained in zigzag pattern was attributed to higher number of tillers and productive tillers per square meter, number of spikelets per panicle, per cent filled grains and 1000 grain weight (Table 1).

Table 1. Effects of different planting patterns on the grain yield, growth and yield components of PSB Rc82 grown under Type II climate. PhilRice AES, Basilisa, RT Romualdez, Agusan del Norte (Experiment 1). July to December 2013 WS

Treatments	Grain Yield (t/ha)	Tiller Count (no/m²)	Plant Height (cm)	Productive Tillers (%)	Panicles (no/m²)	Spikelet/ Panicle (no)	Filled Grains (no/m²)	Filled Grains (%)	1000 Grain Weight (g)	Straw Yield (kg/m²)	Harvest Index
Planting Pattern	**	*	ns	Ns	*	ns	ns	ns	ns	ns	ns
Square Pattern (20x20 cm)	3.68c	356b	98.29	99.15	353b	95	2,464	80.2	25.95	108.55	0.46
Square Pattern (15x15 cm)	4.57b	511a	94.71	97.31	497a	89	1,715	80.6	26.53	81.45	0.44
Rectangle Pattern (15x25 cm)	4.43bc	365b	99.14	93.44	340b	97	2,231	78.8	26.55	109.90	0.43
Triangular Pattern (10-12 cm apart)	5.21ab	429ab	99.25	97.77	419ab	93	2,077	80.5	26.43	111.63	0.43
Zigzag Pattern (10 cm apart)	5.42a	425ab	98.82	99.09	421ab	96	1,456	81.2	26.33	94.63	0.45
R^2	0.83	0.65	0.40	0.46	0.63	0.46	0.38	0.26	0.30	0.54	0.45
cv	7.97	12.91	4.05	3.18	12.13	8.80	31.34	6.38	1.99	14.32	4.14

Means with the same letter within the same column are not significantly different at $p>0.05$.

III. Improving the Resilience of Hybrid Rice and Parent Lines to Climate Change

Project Leader: DAA Tabanao

Due to the growing world population and the decreasing land and water resources for rice cultivation, it has been projected that we need to produce 40% more rice by 2030 to cope with the demand (Khush, 2003). For the Philippines, the rice crisis that the country recently experienced due to the impacts of climate change strengthened its resolve to embark on a rice self-sufficiency program. Hybrid rice is one technology with a lot of promise to contribute greatly to this goal because of its 15-20% yield advantage over inbreds.

The challenges confronting the country`s efforts to achieve staple food sufficiency, particularly that which concerns rice, has evolved into a multi-faceted predicament. For one, Thomas Malthus` theory that global population would grow in geometric proportions while food supply will increase only in arithmetic scales, has held relevance to our local current-day reality. The demand-supply gap of domestic rice industry is still quite wide, due to specific factors including but not limited to low productivity at farmer`s fields, barely increasing areas of production, pest and disease problems, and yield plateau and gaps. To top it all, the effects of climate change has also been taking its toll on domestic rice production and poses a threat, previously underrated, but has now caused alarm making apparent the need to redirect national breeding efforts to achieve the goal of rice self-sufficiency this year and maintain it thereafter.

This project aims to contribute to the adaptation to climate change through the development of climate change-ready and high-yielding hybrid rice varieties. Specifically,it aims to: (1) integrate doubled-haploid and molecular marker technologies in developing hybrids with pest and disease resistance, abiotic stress tolerance, and with high grain yield; (2) improve the heterosis and combining ability of hybrids through widening the genetic base, genomewide selection, and recurrent selection; and, (3) develop new parent lines and F1 hybrids tolerant to abiotic stress and resistant to pest and diseases.

Incorporating stress resistance genes through molecular markers

FP Waing, NRL Sevilla, DA Tabanao

Molecular markers have been proven effective in increasing selection efficiency most especially for traits that are simply inherited. The use of these genetic markers to facilitate the identification of favorable (or deleterious) alleles in a collection of diverse genotypes is referred to as marker-assisted selection (MAS) (Dubcovsky 2004). Over the years of gene discovery in the model crop species Oryza sativa, several genes controlling economically important traits have been fine-mapped and tagged with closely linked or gene-specific markers. When markers are closely linked to a trait of interest, they can be used to indirectly select for the trait, saving time, money and labor. Additional advantages to MAS include the ability to select for multiple alleles underlying a polygenic trait, the ability to select for traits that are difficult or very costly to score phenotypically, are expressed late in the life of the plant, or that require progeny testing due to their recessive nature or a lack of heritability (Koebner and Summers 2003).

This study aims to: (1) incorporate resistance genes to biotic (bacterial blight, tungro and blast) and tolerance genes to abiotic stress (anaerobic germination and submergence) in breeding lines by marker-assisted selection; (2) introgress biotic and abiotic resistance genes and QTL to popular but susceptible public hybrid parent lines; and, (3) assess recurrent parent genome recovery of backcross lines.

Highlights:

- F1 plants introgressed with bacterial blight, tungro and insect resistance genes and QTL were planted in the field in 2013 WS. Leaf samples were collected separately from each F1 plant for DNA extraction and were subjected to target gene assay. Published and functional markers for Xa genes (Xa4, xa5, xa13, Xa21 and Xa23), and SSR markers for tsv1 (RM5495 and RM336), and rtv and Glh (RM16425 and RM16427) were used for heterozygosity testing. Confirmed F1 plants presented in Figure 1 were selected and backcrossed to their recurrent parents to further increase genome recovery.

- F2 populations with introgressed biotic stress resistance that were generated through single cross, backcross and complex cross were planted in the field composed of 200 hills/population. These were comprised of: seven single cross populations, 25 backcross populations, and two complex cross populations. Complex cross was done between B021 (IRBB52/NSIC Rc160//IRBB54/NSIC Rc160) with Xa4, xa5 and Xa21, and B022 (IRBB55/NSIC Rc160//IRBB54/NSIC Rc160) with xa5 and xa13 to pyramid more than two Xa genes and develop a common donor in an adapted genetic background. In each of 15 F2 populations, 20 plants were selected based on PAcp and similarity to the recurrent parent. In the remaining 18 F2 populations, plants were selected based on target gene assay and self-pollinated for generation advance in 2014 DS.

- Field establishment of various pedigree nursery populations with introgressed biotic stress resistance in inbred line development was done. These were comprised of three populations in F6 generation denoted as B002, B007 and B009, and four populations in F4 generation denoted as B011, B018, B019 and B020. Line selections in these populations were carried out based on phenotypic acceptability (PAcp) and similarity to the recurrent parent for generation advance in 2014 DS. In addition, pedigree nursery populations for hybrid parent line development with introgressed bacterial blight and tungro resistance alleles were established. These were comprised of one population in F6 generation denoted as H012 and six populations in F7 generation denoted as H001, H002, H003, H004, H006, and H007. Selection was also carried out based on PAcp.

- Backcross-derived maintainer lines of Mestizo 1 and Mestiso 3 with introgressed bacterial blight resistance genes were established in the field. These were comprised of three populations of improved maintainer lines of Mestizo 1 (PR39905-25B-71-2-1-23, PR39903-25B-52-11-4-16, and PR39904-25B-65-8-1-15), and four improved maintainer and restorer lines of Mestiso 3 (PR39925-97B-36-B, PR39929-97B-50-B and PR39901-97B-36-2). These lines were screened for their reaction to the causal pathogen (PXO79, race 3B) through leaf clipping method. Target gene assay was also performed to confirm the presence of resistance genes. The numbers of lines were as follows: 77 maintainer lines of Mestizo 1 and 58 maintainer lines of Mestiso 3. The disease reaction of these lines ranged from resistant to susceptible based on SES scale and is presented in Table 2.

- DNA samples from six hybrid parent lines were surveyed for polymorphism with published markers (i.e., ART5 and SC3) for the submergence tolerance (Sub1) gene. None among the parent lines showed the allele similar to the IR64-Sub1 (Figure 2). Thus, introgression of Sub1 gene into hybrid parent lines is needed to develop hybrids with tolerance to submergence.

- Segregating populations with introgressed resistance QTL to tungro (tsv1, rtv and Glh) were established at PhilRice branch stations (San Mateo, Isabela, and Murcia, Negros Occidental). These were comprised of one F5 population denoted as B013, three F4 populations denoted as B015, B016 and B017, and three F3 populations denoted as H022, H024 and H025. The reaction of these populations to natural infection of tungro was observed and scored based on SES for rice. Of the 169 lines evaluated, 25 lines were found resistant with infection ranging from 0 to 18.75%, and 11 lines with a moderately resistant score. The resistant lines will be evaluated through PCR assay to verify the presence of resistance QTL using flanking markers in 2014 DS and for generation advance.

- Differential varieties for tungro resistance were evaluated at PhilRice branch stations (San Mateo, Isabela, and Murcia, Negros Occidental) for disease resistance screening. Evaluation of disease reaction was done based on SES for rice. Of the 16 varieties tested, Habiganj DW8 was resistant in Negros and Isabela with disease infection ranging from 0 to 8.3%. In both locations, seven varieties exhibited resistant to moderate resistant reaction, whereas five varieties were susceptible.

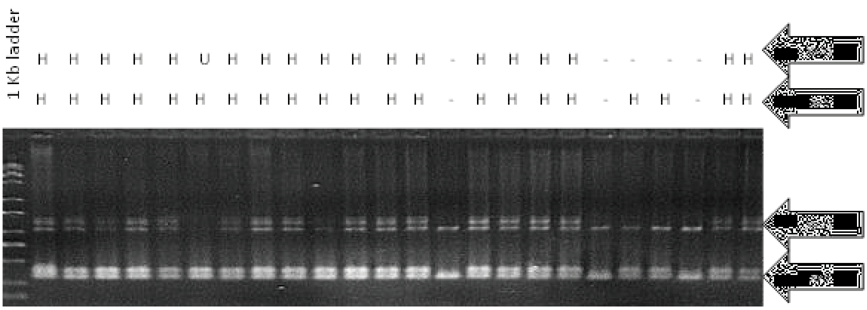

Figure 1. Heterozygosity test in F1 plants using markers for Xa genes (Xa21: upper lane and xa5: lower lane) showing the introgression of both genes. Note: “H” denotes heterozygous allele, “-“ denotes allele pattern similar to recurrent parent and “U” denotes no amplification.

Table 2. Disease reaction of selected backcross derived maintainer lines to bacterial blight.

Entry code	Cross combination	No. lines	*Xa* genes	Lesion length*	Reaction
HB2	IR68897B*2/PR39901-97B-36	39	Xa4, Xa7, Xa21	3.0-8.7	R-MR
HB3	IR68897B*2/PR39901-97B-36	10	Xa4, Xa21	2.7-8.9	R-MR
HB4	IR68897B*2/PR39901-97B-50	9	Xa4, Xa21	2.9-12.0	R-MS
HB5	IR58025B*2/PR39897-25B-71	10	Xa4, Xa7, Xa21	2.5-20.7	R-S
HB6	IR58025B*2/PR39897-25B-65	50	-	1.9-11.8	R-MS
HB7	IR58025B*2/PR39897-25B-52	17	Xa4, Xa21	2.9-12.4	R-MS

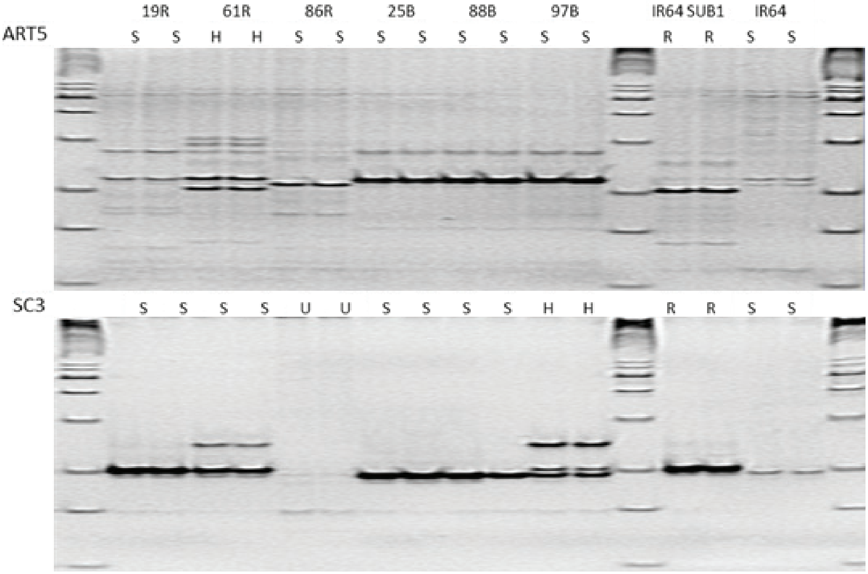

Figure 2. Polymorphism survey for the presence of Sub1 gene in selected hybrid parent lines using ART5 and SC3 markers. Note: "R" denotes resistant allele, "S" denotes susceptible allele and "U" denotes no amplification.

Generating useful variation in hybrid parent lines through induced mutagenesis

MM Rosario, AE Pocsedio, JM Domingo, DA Tabanao

Induced rice mutants have been proven to be useful research tools in genetic and physiological assessment on yield-limiting factors in rice. Moreover, induced mutation can aid isolation of new genes that are not available in the gene pool. In vitro culture (IVC), likewise, induces mutation generating gametoclonal or somaclonal variants which may be exploited to improve or develop new varieties. Doubled haploidy (DH) via anther culture (AC) is one of the most exploited IVC systems. DH technology has recently changed the way inbreds are developed in breeding programs. It greatly reduces the time required to obtain inbreds compared with six or more generations of self-pollination.

This study aimed to: (1) induce mutation in hybrid parent lines using gamma irradiation and in vitro culture (IVC), and, (2) generate mutant hybrid parent lines with drought tolerance and herbicide resistance.

Highlights:

- A total of 104 F1 combinations were subjected to anther culture. Of these, 14 produced calli with 0.01-1.57% callus formation rate (Table 3). However, generated calli became necrotic when transferred to regeneration media.

- Response of four hybrid maintainer lines to tissue culture was assessed. Mature seeds were plated in two culture media: callus induction (CI) and MNKsucrose. As shown in Table 4, of the four hybrid maintainer lines evaluated, IR80151B obtained the highest percent seed callus formation both for CI (66.33) and MNKsucrose (57.67), while other entries did not respond well. Generated calli were sub-cultured to regeneration media for plant development (Figure 3).

- To support the result of the tissue culturability of the four hybrid maintainer lines, germination rate was done in two ways: in vitro (modified MS media) and filter paper method. Based on the findings, IR80151B showed good germination rate in both in vitro and filter paper methods. On the other hand, other entries exhibited good germination both for in vitro and filter paper methods but did not react well to tissue culture.

- A total of 420 calli derived from mature seeds of IR80151B were irradiated with 60Co at the Philippine Nuclear Research Institute. Irradiated calli were transferred onto regeneration media containing 10% polyethylene glycol (PEG) as selectable marker for drought resistance and incubated in the lighted room for plant regeneration.

- During 2013 DS, 28 doubled haploid (DH) plants were generated. A sum of 19 R0 plants survived of which six were haploids. Of the remaining 13 DH plants, three were testcrossed to IR68897A and IR58025A producing seven F1 hybrids and 10 DH plants are still in the glasshouse to be grown until maturity.

- In 2012 WS, eight DH×DH F2 populations were established for plant selection, of which 233 F2 individual plants were selected. F3 plants were established in 2013 DS, of which 402 individual plants were selected. F4 plants were established in 2013 WS, of which 111 plants were selected. Of these, 55 will be testcrossed to three tester lines in 2014 DS.

- For herbicide screening, 200 g seeds each of three hybrid parent maintainer lines were irradiated with 250 Gy of 60Co to induce mutation. Treated seeds (M1) were germinated to grow 1000 plants for each maintainer line in the screenhouse, and M2 seeds will be harvested in 2014 DS.

Table 3. Response of F1 combinations to anther culture (2013WS).

Cross combination	No. of anthers plated	No. of callused anthers	Callus formation (%)	Remarks
lite RxR				
PR34302R/TG101	15,660	69	0.44	
TG101/PR34302R	15,300	37	0.24	
PR34302R/PR36546-HY-1-19	6,480	46	0.71	
TG101/PR36546-HY-1-19	10,440	164	1.57	Most of the calli in regeneration media are necrotic.
IR73885-1-4-3-2-1-10/SRT3	7,240	10	0.01	
Elite BxB				
IR73328B/IR79156B	19,260	63	0.33	
IR68897B/IR79156B	52,920	400	0.76	
IR80559B/IR73328B	8,820	35	0.4	
Line development RxR				
PR36502HY-1/HR167	3,600	7	0.19	
19R52/IR73885-1-4-3-1-1-10R	2,520	2	0.08	
19R52/19R76	3,600	5	0.14	Callus formation is on-going.
IR73885-1-4-3-1-1-10R/PR44826-38-1-1	2,880	21	0.73	
IR73013-95-1-3-2R/PR36244HY-10-1-3	6,660	5	0.08	
IR60819-34-2R/IR73013-95-1-3-2R	1,260	7	0.08	

Table 4. Seed callus formation of hybrid maintainer lines (2013 WS).

Maintainer line	No. of seeds inoculated		No. of seeds with callus formation		Seed callus formation (%)		Remarks
	CI	MNK	CI	MNK	CI	MNK	
IR68897B	300	300	4	5	1.33	1.67	Calli still in the lighted room for plant regeneration.
IR73328B	300	300	0	4	0	1.33	
IR79128B	300	300	6	8	2.00	2.67	
IR80151B	300	300	199	173	66.33	57.67	
Total	1200	1200	209	190			

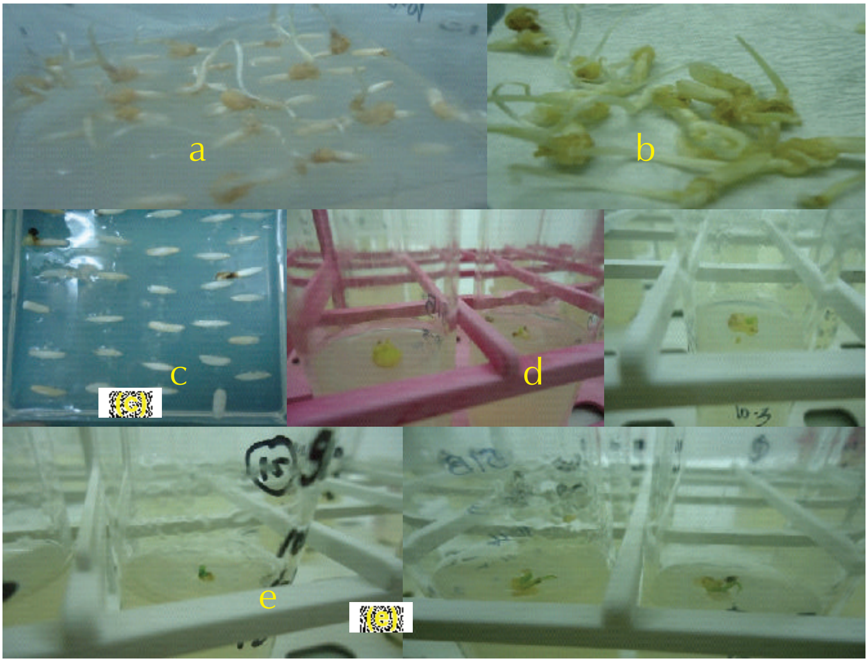

Figure 3. Response of seeds to tissue culture. (a) Mature seeds in callus induction media; (b) Seeds with callus formation; (c) Seeds with no callus formation; (d) Calli in regeneration media; (e) Calli with shoot formation.

Figure 4. M1 plants of irradiated hybrid maintainer lines.

Prospecting in non-hybrid parent lines

JM Domingo, VP Luciano, MM Rosario, DA Tabanao

The sustainability of irrigated lowland rice production is being threatened by freshwater scarcity. For this reason, researches were done to develop water-efficient 'aerobic rice' varieties by combining the drought-resistant traits from upland varieties with the high-yielding traits of lowland varieties (Belder et al., 2005). A big part of the farming cost is devoted to labor and a big part is during the transplanting activity. Direct seeding or broadcast seeding is the mitigation measures being used by farmers to reduce the cost on transplanting. Direct seeding requires less labor and water without compromise to productivity. Aerobic rice cultivation is growing of rice that requires less water than lowland rice with the use of supplementary irrigation and fertilizers aiming for high yields (Wang et al., 2002). Castaneda et al (2002) reported that aerobic rice cultivation saves water due to the elimination of continuous seepage and percolation thus reducing evaporation and eliminating wet land preparation.

This study aimed to: (1) identify potential maintainer lines (B) or restorer lines (R) from non-hybrid parent lines adapted to direct-seeded establishment and aerobic cultivation, and (2) develop F1 hybrids between cytoplasmic male sterile (CMS) lines and breeding lines developed for direct-seeding under lowland culture and aerobic cultivation.

Highlights:

- A panel of 37 elite breeding lines from rainfed, direct-seeded germplasm, and aerobic rice nursery were assembled in 2013 WS. These entries were selected based on their high-yielding ability and adaptability to direct-seeding under lowland culture and aerobic cultivation (Table 5). These lines will be planted and testcrossed to eight CMS lines in 2014 DS. Per se and testcross performance will be evaluated. Percent seed set will be recorded in the testcross progenies and analyzed according to sterility (for maintainer line development) or fertility (for restorer line development).

- Potential maintainer lines will be converted to CMS lines through backcrossing. Potential restorer lines will be re-testcrossed to eight CMS lines, and testcross progenies will be evaluated. Potential maintainer and restorer lines with important traits possessing resistance to different diseases, environmental stresses will be used for improvement of other maintainer and restorer lines in the hybrid breeding project. Yield evaluation and screening for direct-seeding and aerobic adaptation of the selected parent lines and hybrids will also be done.

Table 5. High yielding lines adapted to direct-seeded and aerobic culture to be established in the source nursery for 2014 DS.

Source Code (2013 WS)	Field Code (2014 DS)	Designation
DSR-202 SI	DSR-SN 223	PR39141-11-2-2-B
DSR-203 SI	DSR-SN 224	PR37801-15-1-1-3-2-B-B
DSR-206 SI	DSR-SN 225	PR37825-18-3-2-3-1-B-B
DSR-263 SI	DSR-SN 226	PR 40432-14-2-1-B-B
DSR-5288 ON	DSR-SN 227	PR 41225-6-1-B-B
DSR 5298 ON	DSR-SN 228	PR 40762-43-3-2-B-B
DSR 5302 ON	DSR-SN 229	PR 40285-44-2-1-1-B-B
DSR 5314 ON	DSR-SN 230	PR 40334-119-1-1-2-B-B
DSR 5315 ON	DSR-SN 231	PR 39557-2-2-3-1-3-B-B
DSR 5332 ON	DSR-SN 232	PR 40432-1-1-1-2-B-B
A014-14	A0-SN 316	PR40803-A014-14
A014-136	A0-SN 317	PR40803-A014-136
A014-137	A0-SN 318	PR40803-A014-137
A014-142	A0-SN 319	PR40803-A014-142
A014-147	A0-SN 320	PR40803-A014-147
A014-148	A0-SN 321	PR40803-A014-148
A014-151	A0-SN 322	PR40803-A014-151
A014-153	A0-SN 323	PR40803-A014-153
A014-161	A0-SN 324	PR40803-A014-161
A014-76	A0-SN 325	PR40803-A014-76
A014-80	A0-SN 326	PR40803-A014-80
A014-85	A0-SN 327	PR40803-A014-85
A014-183	A0-SN 328	PR40803-A014-183
A014-185	A0-SN 329	PR40803-A014-185
A014-189	A0-SN 330	PR40803-A014-189
A014-191	A0-SN 331	PR40803-A014-191
A014-194	A0-SN 332	PR40803-A014-194
A014-196	A0-SN 333	PR40803-A014-196
A014-201	A0-SN 334	PR40803-A014-201
A014-105	A0-SN 335	PR40803-A014-105
A014-107	A0-SN 336	PR40803-A014-107
A014-114	A0-SN 337	PR40803-A014-114
A014-120	A0-SN 338	PR40803-A014-120
A014-121	A0-SN 339	PR40803-A014-121
A014-122	A0-SN 340	PR40803-A014-122
A014-124	A0-SN 341	PR40803-A014-124
A014-131	A0-SN 342	PR40803-A014-131

Screening and evaluation of parent lines and hybrids
JM Domingo, FP Waing, MM Rosario, AE Pocsedio, DA Tabanao

The continuous development of high-yielding hybrid varieties that are resistant to pests and diseases and with excellent grain quality is essential to keep up with the increasing demand for rice and the changing environment. As such, there is a need for the development and improvement for biotic resistance and abiotic tolerance of maintainer and restorer lines which are very essential components in the development of hybrid rice.

Abiotic stress is a major factor limiting productivity of rice crops in large areas of the world. Because plants cannot avoid abiotic stress by moving, they have acquired various mechanisms for stress tolerance in the course of their evolution. Enhancing or introducing such mechanisms in rice is one effective way to develop stress-tolerant cultivars. Direct-seeded rice (DSR) cultivation is increasingly being practiced among farmers in both rainfed and irrigated ecosystems (Pandey and Velasco 2002). Labor scarcity, water shortage, and high production cost have become the major driving forces of this shift. Developing high yielding varieties that can withstand flooding during germination and early growth is essential for sustainability of practicing direct seeding for rice crop establishment.

Submergence is one of the major abiotic stress which causes severe damages to rice farms and significantly affecting yield and farmer's productivity particularly in rainfed lowland and submergence-prone rice areas. The development of submergence tolerant rice varieties is one of the possible approaches to address this problem.

This study aimed to: (1) screen parent lines and hybrids for biotic (blast, bacterial blight, tungro) and abiotic stress tolerance (submergence), and adaptability to aerobic cultivation; and, (2) develop new and diverse hybrid parent lines and F1 hybrids tolerant to abiotic stress and resistant to pests and diseases.

Highlights:

Disease resistance screening

- Tungro. Double haploid (DH) restorer lines were evaluated for tungro resistance under natural field conditions at PhilRice branch stations. There were 58 entries established in Isabela and in Negros. The entries were laid out in randomized complete block design (RCBD) with three replications. Scoring was based on SES for rice. All the DH restorer lines were susceptible to tungro in both locations.

- Bacterial blight. There were 31 hybrid parent lines established for disease resistance screening under field conditions. Through leaf clipping method using PXO79 (Race 3), approximately 1-2 cm of the leaf tip was cut with a pair of scissors dipped in bacterial suspension. Lesion length was measured after 14 days. Of the 31 hybrid parent lines evaluated, 13 were moderately resistant with lesion length of 8.36-9.93 cm, 13 were moderately susceptible (10.44–14 cm lesion length) and 5 were susceptible (14.71-18.63 cm lesion length) (Table 6).

Abiotic stress tolerance screening

- Anaerobic seedling survival. Pre-germinated seeds of parent lines and hybrids were established at Central Luzon State University (CLSU) experimental field for anaerobic germination screening. With a seeding rate of 40 kg/ha, the following materials were seeded with their corresponding plot sizes: six F1 hybrids (5 m2), 19 DH restorer lines (2 m2), and 26 maintainer and restorer lines (8 m2). Khao Hlan On and IR42 were used as check varieties. Each plot was surrounded by dikes to retain water maintained at 5 cm depth. Seedling survival rate was estimated in four quadrants of each plot after 7 days of submergence.

- Two hybrids, Mestiso 20 with 28.8% and Mestiso 7 with 12.5% seedling survival rate, showed higher tolerance to anaerobic condition than the tolerant check Khao Hlan On. With seedling survival rate of 1.6-7.5%, Mestiso 19, Mestiso 29 and PR36474H, showed better tolerance than the susceptible check IR42. Mestiso 3 with only 0.3% seedling survival rate was the most susceptible among the entries (Table 7). All DH restorer lines did not survive the anaerobic screening. The restorer line IR73013-95-1-3-2R showed 28% seedling survival rate under anaerobic condition, which was higher than that of the tolerant check Khao Hlan On. Five entries (IR60819-34-2R, IR60912-93-3-2-3-3R, IR73328B, IR73885-1-4-3-2-1-10R, and SRT-3R) showed 5.5-11.2% seedling survival rates, which were higher than the susceptible check IR42 (Table 8).

- Submergence. Forty-two hybrid parent lines and F1 hybrids including the check varieties FR13A, IR64sub1, IR64 and IR42 were grown in seedling trays following randomized complete block design with three replications. The seedlings were submerged 21 days after sowing (DAS) for a period of 14 days or until the susceptible check showed severe symptoms of damage. Water was drained and the surviving plants were allowed to grow to maturity. The total number of seedlings, number of surviving plants and the percent survival were recorded. Scoring was based on the SES for rice. The plants that survived were transferred to the field and were tested for submergence field screening.

- The tolerant check variety FR13A was noted to have the highest seedling survival of 53.3%. Fifteen entries with 20.7-37.3% seedling survival, showed better tolerance to submergence compared to IR64-Sub1. There were 10 entries with 2.5-15.4% seedling survival lower than that of the susceptible check IR64. Seven entries showed 0% seedling survival (Table 9).

Table 6. DH lines evaluated for bacterial blight resistance in 2013 WS.

TCN code	Designation	Lesion length (cm)	Reaction
IR24 (Susceptible check)		15.2	S
IRBB61 (Resistant check)		4.6	R
TCN 1383	PR45588HY-AC	8.4	MR
TCN 1379	PR45586HY-AC	8.6	MR
TCN 1369	PR45582HY-AC	8.7	MR
TCN 1395	PR45593HY-AC	8.7	MR
TCN 1503	PR45628HY-AC	8.7	MR
TCN 1437	PR45604HY-AC	8.9	MR
TCN 1377	PR45585HY-AC	9.4	MR
TCN 1427	PR45603HY-AC	9.4	MR
TCN 1375	PR45584HY-AC	9.4	MR
TCN 1381	PR45587HY-AC	9.6	MR
TCN 1411	PR45600HY-AC	9.8	MR
TCN 1413	PR45602HY-AC	9.9	MR
TCN 1397	PR45594HY-AC	9.9	MR
TCN 1373	PR45581HY-AC	10.4	MS
TCN 1493	PR45624HY-AC	11.1	MS
TCN 1385	PR45589HY-AC	11.1	MS
TCN 1367	PR45580HY-AC	11.3	MS
TCN 1449	PR45605HY-AC	11.4	MS
TCN 1447	PR45606HY-AC	12.0	MS
TCN 1413	PR45602HY-AC	12.4	MS
TCN 1401	PR45596HY-AC	12.5	MS
TCN 1387	PR45591HY-AC	13.3	MS
TCN 1451	PR45607HY-AC	13.3	MS
TCN 1389	PR45590HY-AC	13.6	MS
TCN 1409	PR45599HY-AC	13.6	MS
TCN 1365	PR45579HY-AC	14.0	MS
TCN 1501	PR45627HY-AC	14.7	S
TCN 1363	PR45578HY-AC	16.3	S
TCN 1403	PR45597HY-AC	16.7	S
TCN 1371	PR45583HY-AC	17.0	S
TCN 1405	PR45598HY-AC	18.6	S

Table 7. Seedling survival of F1 hybrids under anaerobic condition.

Entries	Seedling survival (%)
Mestiso 20	28.8
Mestiso 7	12.5
Khao Hlan On (Tolerant check)	10.5
Mestiso 19	7.5
Mestiso 29	2.6
PR36474H	1.6
IR42 (Susceptible check)	1.2
Mestiso 3	0.3

Table 8. Seedling survival of hybrid parent lines under anaerobic condition.

Entries	Seedling survival (%)
IR73013-95-1-3-2R	28.0
Khao Hlan On (Tolerant check)	12.1
IR60819-34-2R	11.2
IR60912-93-3-2-3-3R	10.7
IR73328B	10.3
IR73885-1-4-3-2-1-10R	9.3
SRT-3R	5.5
IR42 (Susceptible check)	4.2
IR80559B	2.2

Table 9. Hybrid parent lines evaluated for submergence tolerance screening.

Entry No.	Designation	Seedling survival (%)
1	FR13A (Tolerant check)	53.3
2	IR80151B	37.3
3	PR36020H	36.9
4	PR34302R	33.9
5	IR73328B	33.3
6	NSIC Rc116H	32.5
7	PR36474H	25.0
8	IR80559B	24.6
9	IR60819-34-2R	24.2
10	PR21B	23.6
11	SRT-3R	23.5
12	PR35664H	22.4
13	PSB Rc28	21.6
14	MATATAG-2-25kr-63-4-3-2R	21.4
15	IR73885-1-4-3-2-1-10R	20.7
16	IR72889-69-2-2-2R	20.7
17	IR64-Sub1 (Tolerant check)	20.5
18	AC-66-1R	20.2
19	IR73328B	19.4
20	PR2B	18.5
21	PR35749-HY-R	17.2
22	NSIC Rc136H	16.5
23	PR31559-AR-32-4-3-2R	15.8
24	IR64 (Susceptible check)	15.7
25	IR73013-95-1-3-2R	15.4
26	PR34142-5-1-3-2R	15.3
27	NSIC Rc202H	12.3
28	NSIC Rc204H	11.6
29	IR60189-34-2R	10.6
30	NSIC Rc244H	10.1
31	IR60912-93-3-2-3-3R	7.5
32	IR80156B	7.4
33	IR31885-3-1R	7.2
34	PSB Rc72H	2.5
35	IR42 (Susceptible check)	2.1
36	PR36559H	0
37	PR3B	0
38	PR9B	0
39	PR15B	0
40	IR68897B	0
41	IR79123B	0
42	IR79156B	0

IV. Enhancing the Adaptive Capacity of Rice Farmers through Diversification of Household Sources of Food and Income

Project Leader: RF Orge

A lot of studies show that resilience to CC can best be achieved through diversification of sources of income (Brklacich et al. 1997, Smithers and Smit 1997, de Loë et al. 1999, Kelly and Adger, 2000, Smit and Skinner, 2002). Thus the growing of rice, being highly sensitive to extreme climate events (Singh et al., 2011), needs to be complemented with other income-generating activities that will maximize the income that can be generated from a limited piece of farm land tilled by the farmers.

Evaluation of alternative production systems for flood-prone rice environments

RG Corales, JM Rivera, VT Dimaano, FS Grospe, and CA. Asis Jr.

The Philippines ranked 3rd most vulnerable country to climate change due to its geographical location and archipelagic structure (Climate Change Vulnerability Index, October 2011). The agriculture sector, particularly in rice production, is the hardest hit by aggregate impact of climate change. Analysts from the Asian Development Bank (ADB) projected that Philippine rice production might decline to as much as 75 percent from current levels starting in 2020 unless effective and efficient mitigation and adaptation measures are taken to enhance the resiliency and flexibility of rice farming community in facing climate change (Manila Times, 2009).

The Climate Change Program of the University of the Philippines Los Banos (UPLB) projected that 10 flood-prone provinces will be most adversely affected by sea level rise (Manaytay, 2010). Flooding is one of the most significant climate-related problems in the country affecting many flood-prone rice farming communities. The farms in the flood-prone communities are usually flooded for a period of five months (June to October) or more depending on the extent of the monsoon season. Crops are usually grown after the monsoon season to provide food and income for the farming communities but in most cases they are not enough to sustain their daily needs especially during the monsoon season in which food is scarce and expensive. One way of enhancing the resiliency of these farming communities is by providing them with an alternative production system that will enhance productivity and income during pre-and post monsoon season and/or during the monsoon season.

The study aims to: (a) evaluate rice-duck as alternative production systems that can enhance productivity during the pre-and post monsoon season and source of additional income during the monsoon season, and (b) evaluate floating garden as source of food and additional income during the monsoon season.

Highlights:

Rice-duck production system

- The integration of 500 or 1000 ducks/ha did not affect the yield of rice in both dry and wet season. The same effect was also noted on the yield components

- During the dry season, the additional income from duck integration was Php 21,000.00 for the 500 heads/ha and Php 31,000.00 for the 1,000 heads/ha (Table 10). During the wet season, on the other hand, an additional income of Php 25,000 for 500 heads/ha and Php 42,000.00 for the 1,00 heads/ha was attained (Table 11).

- The total income of duck integration over sole rice crop was increased by 33% for 500 ducks and 40% with 1,000 ducks during the dry season. During the wet season, the income was increased by 59% with 500 ducks and 68% with 1,000 ducks.

- The arthropod population was generally low in all treatments

- The water quality was similar in all treatments except a slight increase in the nitrogen level in treatments with ducks.

Floating gardens

- In 2013 dry season, the yield performance of tomato did not vary significantly regardless of soil thickness in the floating raft gardens except in terms of the number of fruits per plant, fruit size, and number of non-marketable fruits per plant at p-value 0.05 using t-test (Table 12). This indicates that 10 cm soil thickness is already appropriate in floating gardens which can efficiently reduce the plastic bottle and other material requirements and consequently lessen the cost of inputs in constructing the floating beds.

- The maturity of tomato fruits grown in the floating raft gardens was recorded at 62 DAT which was relatively delayed compared to the conventional maturity of 55 to 60 DAT. The weight of fruits/plant ranged from 38.53g to 43.37g, lower than the average weight in land-based cultivation which ranges from 50-60 g.

- In 2013 wet season, different crops, such as leafy, solanaceous, and legumes, were evaluated in water hyacinth floating gardens. Among the leafy vegetables evaluated, upland kangkong adapted better than pechay and mustard. Splashing due to heavy rains that occurred during the conduct of the experiment may have caused the low growth rate of pechay and mustard. On the other hand, among the solanaceous crops evaluated, only tomato reached the fruiting stage but low yields were obtained. Eggplant and pepper adapted only until flowering stage and eventually wilted. The weak adaptability can be due to the high moisture content of the decomposed water hyacinth substrate.

- Bush sitao was used as legume crop in the water hyacinth floating garden. Results showed that 1st priming was noted at 38 DAT. Highest yield was recorded at 55 DAT and gradually decreased until 74 DAT.

Table 10. Economic analysis of duck integration in rice production systems. PhilRice CES. 2013 DS

Particulars	Rice Production Systems		
	Sole Rice	Rice + 500 Ducks	Rice + 1000 Ducks
Rice Production (NSIC Rc202H)			
Yield (t/ha)	8.15	8.76	8.82
Price (Php/kg)	15.00	15.00	15.00
Gross Income (Php)	122,250.00	131,400.00	132,300.00
Expenses	60,408.00	60,126.60	60,749.20
Net Income (a)	61,842.00	71,273.40	71,550.80
Duck Production (Pateros sp.)			
Mortality Rate (%)		11	19
Net Stock		445	810
Price (Php/head		130.00	130.00
Gross Income		57,850.00	105,300.00
Expenses		37,007.97	74,015.94
Net Income (b)		**20,842.03**	**31,284.06**
Integrated Income			
Total Income	122,250.00	189.250.00	237,600.00
Total Expenses	60,408.00	97,134.57	134,765.14
Total Net Income	61,842.00	92,115.43	102,834.86
Income Increment (%)		33	40
ROI	1.02	0.95	0.76

Table 11. Economic analysis of duck integration in rice production systems. PhilRice CES. 2013 WS.

Particulars	Rice Production Systems		
	Sole Rice	Rice + 500 Ducks	Rice + 1000 Ducks
Rice Production (NSIC Rc238)			
Yield (t/ha)	4.02	4.52	4.41
Price (Php/kg)	15.00	15.00	15.00
Gross Income (Php)	60,300.00	67,800.00	66,150.00
Expenses	38,961.20	40,991.20	40,544.60
Net Income (a)	21,338.80	26,608.80	25,605.40
Duck Production (Pateros sp.)			
Mortality Rate (%)		3.6	10
Net Stock		482	900
Price (Php/head		130.00	130.00
Gross Income		62,660.00	117,000.00
Expenses		37,507.97	75,015.94
Net Income (b)		**25,152.03**	**41,984.06**
Integrated Income			
Total Income	60,300.00	130,460.00	183,150.00
Total Expenses	38,961.20	78,499.17	115,560.54
Total Net Income	21,338.80	51,960.83	67,589.46
Income Increment (%)		59	68
ROI	0.55	0.66	0.58

Table 12. Yield performance of tomato in floating raft garden as affected by different soil thickness. PhilRice CES, Science City of Muñoz, Nueva Ecija. 2013 DS.

Treatments (soil thickness)	Plant height (cm)	No. of fruits/plant	Weight/ fruit (g)	Fruit Size (cm)	Yield/plant (kg)	No. of marketable fruits/plant	No. of Non-marketable fruits/plant	% Marketable	% Non-marketable
15cm	96.46a	31.01a	38.53a	4.01a	1.05a	21.48a	9.53a	69.25a	30.75a
10cm	96.21a	25.90b	43.37a	4.27b	1.03a	19.94a	5.96b	77.09a	22.91a
p-value at 0.05	0.92998	0.03076	0.22658	0.00713	0.83362	0.3269	0.02303	0.07469	0.07469

Enhancing resiliency of rice – producing households in flood – prone areas of Caraga Region
ST Rivas and CA Mabayag

Caraga Region (Region 13) was identified by national weather and climate agencies as one of the most sensitive regions to climatic irregularities. The "Ready Project" (Hazard Mapping and Assessment for Effective Community-Based Disaster Risk Management) of the National Disaster Risk Reduction Management Council identified Agusan Del Sur, Surigao Del Sur, and Surigao Del Norte as among the "27 high-risk provinces" in relation to climatic irregularities and natural disasters (2011). In addition, the Geohazard Map of Mines and Geosciences Bureau of DENR (gdis.denr.gov.ph, 2013) and the Flood Map of "Project Noah" of DOST (noah.dost.gov.ph, 2013) confirmed the susceptibility of these provinces to flooding. Furthermore, flooding is expected to escalate in the next 20 years as PAGASA projected that there would be more occurrences of floods due to the increased performance of northeast monsoon particularly in provinces characterized under Type ll climatic regime (Climate Projections in the Philippines, 2011).

It is also noteworthy that Caraga Region is among the poorest regions in the country. The 2012 1st semester report of the National Statistical Coordination Board showed that 34.1% of the total households in the region are living below the poverty threshold. Agriculture remains an important industry in the region; and the source of livelihood for the 38.6% of its workforce. Rice yield across location is at 3.0 t/ha (BAS, 2013).

In view of the background presented above, it is with valid reason to believe that among the most vulnerable to shocks brought about by climate change, specifically flooding, are the economically – disadvantaged rice – producing households in flood – prone communities in the region. Flooding will definitely affect the meager agricultural production, which might escalate food insecurity and income insufficiency. Negative circumstances brought about by climate change will definitely amplify socioeconomic problems already experienced by the region.

Highlights:

- The identified sites of the study based on established criteria are (1) Brgy. Zillovia, Talacogon (Fig. 5), (2) Brgy. Sta. Ana, San Francisco, (3) Sitio Antioquia, and (4) Brgy. Kapatungan, Trento. Focus group discussion (FGD) was scheduled in each target sites initially to assess the rice production systems, flooding history, and coping mechanisms of farmers and its households during flooding events.

- From the FGD conducted in Trento, Agusan del Sur, information related with farming practices were gathered particularly those that pertains to varietal selection, land preparation, crop establishment, nutrient management, water management, pest management, postharvest management and marketing.

- In terms of their coping mechanism to flood, farmers start their field operations in midf January to avoid damage/losses due to flood. Farmers diversify their sources of income by going into hog raising, duck raising (rice-duck farming), carpentry, driving single motorcycle (habal-habal) to provide transport service in rural areas, as well as working as hired labor in oil palm plantations, among others. These farmers have not tried planting water submergence tolerant rice varieties. They emphasized that they prefer varieties with good eating quality because they also utilize their produce for personal consumption.

Figure 5. Rice field located in a flood-prone area, Talacogon, Agusan Del Sur

Maximizing the use of the continuous rice hull (CtRH) carbonizer in generating additional sources of income for enhanced climate change resiliency of rice farming communities

RF Orge, JEO Abon and HB Alfon

A lot of studies show that resilience to climate change can best be achieved through diversification of sources of income (Brklacich et al. 1997, Smithers and Smit 1997, de Loë et al. 1999, Kelly and Adger, 2000, Smit and Skinner, 2002). If one source of income fails, there should be another source or sources of income that would provide the needed financial support so the farming households can withstand or recover from any climate change related stresses or shocks that they may experience.

One possible way of increasing the farmers' productivity and of providing them opportunities for generating additional sources of income is through the use of the PhilRice-developed continuous rice hull (CtRH) carbonizer. This carbonizer was developed to process rice hull into biochar (charcoal) with very minimal smoke emission while recovering the heat for some applications which could provide additional income opportunities for rice farming households (Orge, 2010). Thus, while producing biochar as soil conditioner, animal bedding, or as ingredient in organic fertilizer production for improved farm productivity, high value products can be produced for additional income of the farmers.

In general, this study aims to provide additional income opportunities for the rice farming households/communities as a way of enhancing their resiliency to climate change, making use of the PhilRice-developed continuous rice hull (CtRH) Carbonizer. Specifically, it aims to:

1. Develop heat recovery attachments to the CtRH carbonizer for making use of the heat in processing food and high value products as additional source of farmers' income;

2. Pilot test a carbonizer-based income-generating (CBIG) activity in selected rice farming households/ communities.

Highlights:

- Two attachments to to the CtRH carbonizer were designed, fabricated and tested. The first one was a cooking attachment designed for high volume cooking (Fig. 6). A distilling apparatus was also designed and fabricated for use together with the cooking attachment. With it, extracting essential oil from medicinal plants can also be done. The second one is an oven (Fig. 7) which can be used for a variety of uses: baking bread (pandesal), native cakes and other related food products (bibingka, tupig, etc.) as well as roasting..

- Results of the water boiling test conducted for the cooking attachment showed that it took 31.8 minutes to boil 30 liters of water, consuming rice hull at a rate 12.45 kg/h with a biochar yield of 42.33%.

- Initial test results for the oven showed a maximum temperature of 250oC obtained inside the oven. The inside temperature can be controlled by a valve which controls the passage of hot gas (products of combustion) either into the walls (external surface) of the inner chamber of the oven or directly to the chimney. More tests shall be done to test the performance of the oven using actual products.

Figure 6. Cooking attachment for the CtRH carbonizer

Figure 7. The oven attached to the CtRH carbonizer.

Abbreviations and acronymns

ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit

LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
$mtha^{-1}$ - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

List of Tables

List of Figures

Department of Agriculture

PHILRICE

PHILIPPINE RICE RESEARCH INSTITUTE

We are a chartered government corporate entity under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding, cost-reducing, and environment-friendly technologoies so farmers can produce enough rice for all Filipinos.

We accomplish this mission through research and development work in our central and seven branch stations, coordinating with a network that comprises 57 agencies and 70 seed centers strategically located nationwide.

To help farmers achieve holistic development, we will pursue the following goals in 2010-2020: attaining and sustaining rice self-suffiency; reducing poverty and malnutrition; and achieving competitiveness through agricultural science and technology.

We have the following certifications: ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environment Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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CERTIFICATION INTERNATIONAL
ISO 9001:2008 CIP/4360IQ/09/10/668
ISO 14001:2004 CIP/4360IE/09/10/668
OHSAS 18001:2007 CIP 4360ISH/09/10/668