Philippine Rice R&D Highlights 2013

PLANT BREEDING and BIOTECHNOLOGY DIVISION

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PLANT BREEDING AND BIOTECHNOLOGY

Division Head: Thelma F. Padolina

Executive Summary

Genetic improvement of crops will be the most viable approach to increasing food production in the future. Biotechnology can also be involved at different stages of its breeding process. The rice breeding program in PhilRice focuses, first, on pre-breeding activities and germplasm enhancement that trails into the development of rice varieties and lastly, improved seed multiplication while maintaining its genetic purity.

Breeders continue to search for genetic variability for broadening the gene pool of rice cultivars. The purpose is to be at least one jump ahead of the environmental uncertainties which could threaten future rice yields. In 2014, characterization of donor germplasm in the breeder's crossing block was done and 169 donor parents were used in breeding for inbred irrigated lowland. Molecular diversity showed a high Shannon-Weaver diversity index of 0.69. Though, less diversity was observed in terms of the maturity of entries. Currently, outstanding lines derived from non-conventional and innovative techniques are entering advanced stages of breeding and show worthy potentials. Three induced mutants of a traditional variety (Ballatinaw) and 10 ultra-early maturing elite lines are being evaluated in the Multi-Environment Trials (MET). Backcrosses from Oryza rufipogon and japonicas show prospective as hybrid parents by performing better than Mestiso 1. In terms of disease resistance and diagnostics, a promising blast screening site was identified in NOMIARC. 60 assembled blast materials will be tested in NCT test locations. For grain quality, five cultivars were selected as potential parentals for crack resistance breeding (mainly using the brown rice exposure method) and molecular studies shall be further characterized. These include NSIC Rc160, PSB Rc52, Rc38, Burdagol and IR42.

Breeding's ultimate goal is to develop rice varieties based on improved yield, resistance to pest and disease and good grain quality. As such, hybrid rice breeding constantly develops parent lines and F1 hybrids that are tested primarily for grain yield in performance trials. During the wet season 2 line and 3 line hybrid parents were identified. A new CMS lines with stable sterility and good agronomic characters will be used as new testers in the Source Nursery. CMS lines with PR35746-HY-6-6-2-1-1-1 background will be seed produced and will be characterized in 2014. On the other hand, two highly selected TGMS hybrid pollen parents (TG101M and TG102M) are being morphologically tagged with purple coloration at the leaf sheath base through backcrossing. One promising hybrid designated as PRUP 10 was entered in the 2013 wet season trial of the NCT. This hybrid had a yield advantage of 29.5% over PSB Rc 82, medium maturing and grows to a height of around 108 cm. Meanwhile, specialty rice that

commands higher market price and golden rice introgressions are constantly progressing. Conventional breeding that is geared towards increasing productivity without altering the specific specialty characters are being done. Breeding efforts resulted to two pigmented elite lines that are for possible plant variety protection (PVP) owing to its good sensory characteristics and suitability to brown rice. In Golden rice backcrosses, introgression is continually done while the selected PSB Rc82xGR2-R-B3-117-10-3-33-12 was taken to Golden Rice multi-location trial site.

Moreover, as we recognize the vital role of the rice seed industry in this modern revolution, efficiency in the rapid seed increase of new varieties, and effective maintenance of their genetic purity are critical to increase and sustain rice production in the country. Each of the 105 varieties was rigorously selected for new source seeds of breeder's seed production. This resulted to a total of 14,550 heads selected. 42% of the varieties and elite lines were also successfully characterized using IRRI descriptor for rice and UPOV.

Given these undertakings, rice breeding demonstrates to be a progressing endeavor that gives a great prospective in benefitting rice farming profitable, sustainable and competitive.

I. Pre-Breeding and Germplasm Enhancement

TF Padolina

Genetic enhancement for crop plants has become necessary in recent years to broaden the relatively narrow genetic base of modern crop cultivars selected for higher productivity. Such broadening is needed to supply new kinds of pest resistance, to bring in new levels of productivity and stability of performance, and to provide useful new qualities to food and feed products. With the advent of biotechnology, it will provide essential and innovative support to standard plant breeding to bring in new generic systems, new techniques for selection and identification of genotypes, new ways of making hybrid crops, and, most importantly, deeper understanding of plant gene action, biochemistry and physiology. In addition to broadening the genetic base of established crops, genetic enhancement-and plant breeding in the sense of final cultivar development-can be used in two other ways: to develop new crops from heretofore uncultivated species, and to change old crops into new crops.

Challenges are great and breeders continue to search for genetic variability for broadening the gene pool of rice cultivars to develop genetic vulnerability, a direct by-product of successful plant breeding. The resulting new cultivars can display a greater diversity because new gene sources, unrelated breeding materials have been introduced into basic and advanced breeding pools. Non-conventional and innovative techniques are applied for the creation and transfer of variability. Several genes are now being pyramided through molecular marker-aided selection with a view to increasing durable resistance. New and better ways of disease diagnostics are also being developed. Studies on the elucidation of the genetic basis of some diseases, yield, and grain quality traits are now underway. The pre-breeding materials developed out of these studies will pave new opportunities for further genetic improvement of our breeding pools.

Induced mutations for rice quality
RC Braceros and LR Pautin

Continuing evaluation of advanced generation mutant lines from different backgrounds have been done in 2013. Different grain quality determination on physical and milling potentials, physico-chemical traits and some value-adding traits such as low phytic acid screening for all available mutants have been prioritized. Acceptable yield and other morpho-agronomic traits were assured for all the mutant materials. Modern varieties such as PSB Rc10, NSIC Rc152, NSIC Rc150 and MS16 were targeted to reduce chalkiness, improve physico-chemical properties and milling quality, respectively. Traditional varieties like Azucena, Dinorado and Ballatinaw were also chosen to improve yield while retaining good grain quality. Some advanced mutant lines were also crossed to donor parents possessing resistance/ tolerance to various stresses.

Highlights:

- For MS16-25Kr (Laila), out of 21 lines evaluated for kernel quality 14 were selected with medium, long slender, slim type of grain with white belly and dull grain.

- From the 30 PSB Rc10-25Kr mutants analyzed for amylose content, only 5 lines were selected with better kernel quality compared to original PSB Rc10.

- 10 lines selected with very good grain, long slender grain, and translucent, very soft grain but with white belly were selected from the 30 NSIC Rc150-20Kr mutants chemically analyzed for amylose

- 15 lines of NSIC Rc152-25Kr mutants were selected from 36 lines evaluated for kernel quality testing with dull and long slender grain. Amylose content will also be determined in the next testing

- For 2013WS, 37 lines of Dinorado Susi mutants evaluated including original check Dinorado, 24 lines passed the kernel quality test with good to excellent grain quality, medium to long type of grain (Tabla 1). Two Dinorado lines were elevated to MET0 for 2014DS trials.

- 15 Ballatinaw mutants were selected for kernel quality from 36 lines evaluated with medium to medium slender and pigmented glutinous type of grain.Three Ballatinaw mutant lines were evaluated to MET 0 and MET1 last 2013WS trials. Some lines of Ballatinaw were also analyzed for grain quality as a result.

- For the yield performance of PSB Rc72H-mutant, 5 lines were performed best on their yield with an average yield of 6.4 to 8.7 tons/ha during 2013WS. 36 lines evaluated for kernel quality testing, 10 lines (PR37901) were selected with good kernel quality of medium slender to long slender type of grain, translucent and dull grain compare to original Mestizo 1 with long grain type with white belly (Table 2a).

- Among Azucena mutants evaluated for grain quality analysis, 2 lines were passed with G1 classification in Milled rice, good in physical attributes, intermediate amylose content and high to intermediate gelatinization. For the yield performance this two lines passed for grain quality yield almost 5.13 and 5.09 tons/ha (Azucena-30KR-6-5-1, Azucena-30KR-7-6-1) (Table 2b).

Table 1. Grain quality analysis of passed Dinorado mutant lines

	Milling Recovery						Physical Attributes						Physicochemical Properties			
Index Number/ Source	Brown Rice (%, Class)		Milled Rice (%, Class)		Head Rice (%, Class)		Grain Length (mm)		Grain Shape (L/W)		Chalky Grains (%, Class)		Amylose Content (%, Class)		Gel. Temp. (ASV, Class)	
15	77.8	F	69.7	G1	45.0	G2	6.5	M	3.1	S	3.1	G1	17.8	I	6.7	L/I
21	75.8	F	69.1	G1	35.7	G3	6.6	L	2.5	I	4.4	G1	17.9	I	5.3	I/L
23	76.1	F	69.4	G1	31.0	G3	6.5	M	2.5	I	3.2	G1	22.9	I	5.1	I
26	75.5	F	69.2	G1	34.5	G3	6.6	L	2.5	I	2.6	G1	19.6	I	5.0	I
27	76.4	F	70.2	Pr	31.0	G3	6.5	M	2.6	I	4.3	G1	22.4	I	5.0	I

Table 2a. Agronomic performance of Mestizo mutant

r e	Moisture Content (%)	Milling Recovery: Brown Rice (%, Class)	Milling Recovery: Milled Rice (%, Class)	Milling Recovery: Head Rice (%, Class)	Physical Attributes: Grain Length (mm)	Physical Attributes: Grain Shape (L/W)	Physical Attributes: Chalky Grains (%, Class)	Physicochemical Properties: Amylose Content (%, Class)	Physicochemical Properties: Gel. Temp. (ASV, Class)
	12.3	75.8 F	66.2 G1	35.9 G3	6.7 L	3.2 S	3.1 G1	21.1 I	2.8 H/ H-I
	12.5	75.1 F	65.3 G1	31.7 G3	6.6 M	3.2 S	2.9 G1	21.0 I	2.8 H-I

Table 2b. Grain quality analysis of passed Azucena mutant lines

Index Number / Source	Moisture Content (%)	Milling Recovery: Brown Rice (%, Class)	Milling Recovery: Milled Rice (%, Class)	Milling Recovery: Head Rice (%, Class)	Physical Attributes: Grain Length (mm)	Physical Attributes: Grain Shape (L/W)	Physical Attributes: Chalky Grains (%, Class)	Physicochemical Properties: Amylose Content (%, Class)	Physicochemical Properties: Gel. Temp. (ASV, Class)
21	12.3	75.8 F	66.2 G1	35.9 G3	6.7 L	3.2 S	3.1 G1	21.1 I	2.8 H/ H-I
26	12.5	75.1 F	65.3 G1	31.7 G3	6.6 M	3.2 S	2.9 G1	21.0 I	2.8 H-I

Development of herbicide tolerant and disease-resistant rice through induced mutations

AA Alfonso, RB Miranda and ES Avellanoza

The genetic variation of modern rice varieties has narrowed as a result of decades of breeding. To be able to continue to make gains from rice breeding, access to a diverse natural germplasm is essential. Induced mutation is one strategy to produce novel genetic variation that can be exploited for varietal improvement. Among the important factors that adversely affect yield are diseases and weeds, especially with the changing climatic patterns. This study, therefore, aims to enhance the genetic variation in the PhilRice rice varietal development program specifically for disease resistance and tolerance to herbicide.

Highlights:

- Generated 293 individual plants of NSIC Rc144 and 255 individual plants of NSIC Rc192 mutated at 1.5% EMS. Seed increase 47 M2 plants from NSIC Rc192 mutated at 1.5% EMS treated in cold and identified one mutant with new plant type from wild type NSIC Rc192.

- Selected 62 putative short lesion mutants (SL) of 1.5% EMS mutated NSIC Rc192, five from NSIC Rc288 and 17 from NSIC Rc272.

- Confirmation of broad-spectrum resistance of NSIC Rc144 mutant, MSL 37 and MSL 40

- We had determined the mode of inheritance and estimated the number of genes of the underlying mutation, we had crossed the MSL lines to IR24 and performed disease screening on the F1 and segregating F2 progenies resulting from the crosses. . All the F1 plants exhibited susceptible reaction indicating that the observed resistant phenotype in the mutants is due to recessive mutation. BB reaction of F1 and segregation in F2 indicate that a single recessive gene control the observed resistance.

- We selected 196 M3 putative tungro resistant (111 EMS derived and 85 Irradiated), 237 intermediate (157 EMS derived and 80 Irradiated) and 134 resistant and 114 intermediate M5 plants from CV. NSIC Rc192. (Table 3)

- Mass screening of 1.5kg M3 plants for glyphosate tolerance did not identify any tolerant plants

- Produced and seed increased eight new crosses using MSL 37 and MSL 40 crossed to wild type NSIC Rc144 and six IRBB lines for genetic study to determine if the gene involved is dominant or recessive and elucidate molecular mechanism of BB resistance in these mutants.

- Preliminary yield trial of MSL 37 and MSL 40 were evaluated and resulted to a yield advantage of 13 and 18%, respectively over the wild type NSIC Rc144.

- 57 long grain mutants (LG) of NSIC Rc192 were also selected for and will be evaluated for segregation/stability analysis

- Other significant accomplishments are:
  - Best poster awardee during the Annual Scientific Conference of the Pest Management Council of the Philippines (PMCP) on March 5-8, 2013 "Radiation-Induced Mutant of NSIC Rc144 with High Resistant to Bacterial Blight"

  - Silver awardee during the 25th DA-BAR National Research Symposium for the paper entitled "Radiation-Induced Mutant of NSIC Rc144 with Broad-Spectrum Resistance to Bacterial Blight"

Table 3. Evaluation of NSIC Rc192 (M3) for RTV resistance screening

Entry Code	No of Entries	BLB Rating		
		R	I	S
NSIC Rc192-1	20	73 (17)	24 (12)	303
NSIC Rc192-2	17	34 (15)	62 (10)	244
NSIC Rc192-6	10	16 (7)	18 (5)	166
NSIC Rc192-13	5	10 (5)	7 (3)	83
NSIC Rc192-18	2	1 (1)	3 (1)	36
NSIC Rc192-19	1	0	0	20
Total	55	134	114	852
Control Checks Reaction to RTV				
Rc192 (WT)	1	0	5	15
TN1 (S)	1		2	18
IR64 (S)	1		1	19
ARC (R)	1	13	0	7

Breeding for ultra-early maturing rice varieties with high yield
TF Padolina and LR Pautin

The breeding and development of highly productive lines that are ultra-early or mature in less than 100 days (some farmers even clamor for 75-day varieties of rice) is not only a fascinating challenge to plant breeders. It is an important and timely breeding objective to pursue. The government through the Department of Agriculture has recently crafted an intensified campaign to increase our rice production further and attain rice self-sufficiency in the process. Ultra-early maturing varieties offer sustainable breakthrough interventions not only to increase total productivity under favorable conditions but under the less favorable environments as well – considering the impacts of water availability in the physical rice environment, of climate change on the timing and length of production seasons, and of dwindling lands for rice cultivation.

The practice of a shorter production cycle using ultra-early varieties promotes higher efficiency of fertilization and even reduces the production costs since it also shortens the vulnerable time of the crop to pest attacks in the field and thereby minimizes the application of pesticide inputs. In well irrigated fields, ultra-early maturing varieties could provide the soil with a longer "rest" period (fallow) for dry matter incorporation. Another advantage is it can help break the pest cycle.

Highlights:

- For the 2013 hybridization works, it generated 35 single crosses (SC) for dry season and 40 SC in wet season with ultra early traits and with good eating quality.

- In the pedigree nursery, conventional lines in the F8 generations with maturity of 100-105 days (very early maturing) and 106-110 days (early maturing) with good phenotypic acceptability and uniformity were selected. Ten outstanding entries were elevated to MET 0 this 2014 dry season (Table 4).

- The yields of the tests entries range from 4.9 ton/ha to 8.5 in very early maturing lines and 5.8 to 9.6 ton/ha were recorded in the early maturing. Seven entries were out yielded in IR 58 and PSB Rc4, while three are not significantly different to 10-OM check at very early maturing. While six entries were out yielded in early maturing lines over the three checks, six entries were not significantly different from the checks.

- A total of 108 M4 populations were selected in relation to earliness, plant height, grain size and high yielding ability. Early maturing was observed in different treatment, while late maturing observed in control (Figure 1 and 2).Yield and agronomic data were gathered this 2014 DS, processing of data still on-going.

- Summary of grain quality data; Brown Rice observed that Twenty entries classified as Fair (F1), 75.1- 79.9% and Seven entries with IR58 (control) classified as Good (G), >80%. Milled Rice identified Sixteen entries with IR58 classified as Premium (Pr), >70.1% and Eleven entries for Grade 1 (G1), 65.1- 70.0%. Twenty one entries with IR58 classified as Grade 1 (G1), 48.0- 56.9% and Six entries classified as Premium (Pr), >57% for Head Rice result. These materials classified in long to medium grain length, slender to intermediate grain shape, five were classified in premium and twenty four with IR58 are Grade (G1) in percent chalkiness.

Table 4. List of UEM materials for MET 0, 2014 Dry Season

Pedigree No.	Cross combination	PA	MAT	yield (tha-1)
PR40348-7-5-1	IR 58 X NSIC Rc 140	3	102	4.9
PR40366-2-2-1	PSB Rc 10 X NSIC Rc154	3	105	6.1
PR40356-5-3-2	PSB Rc 4 X NSIC Rc 150	3	105	7.5
HPNS-127-2-2	PR36248-HY-2-3-3/PR37046-B-3-3-7(G)	3	102	8.4
PR40364-4-1-1	NSIC Rc 154 X IR 58	5	105	8.5
PR40346-4-2-1	IR 58 X NSIC Rc 150	5	109	8.5
PR40356-1-5-3	PSB Rc 4 X NSIC Rc 150	3	107	8.3
PR40408-6-2-2	PSB Rc 10 X NSIC Rc140	3	100	7.8
PR40366-2-1-1	PSB Rc 10 X NSIC Rc154	3	106	7.6
PR40408-6-1-1	PSB Rc 10 X NSIC Rc 140	5	101	8.1

Figure 1. NSIC Rc134 with different treatments

Figure 2. PSB Rc10 treated with 250 Gy

Exploring the genetic diversity hidden in wild rice and Japonicas to lift the yield barrier

DA Tabanao and MM Rosario

Variation plays a vital role in the success of crop genetic improvement, so plant breeders need to rely on a rich source of genetic variation. The advent of molecular marker technology and the derived quantitative trait loci (QTL) mapping technology have provided strong evidence that despite the inferior phenotype, exotic germplasm is likely to contain QTLs that can increase the yield and quality of elite breeding lines. At PhilRice, improvement of hybrid parent lines relies mainly on crosses within the indica subpopulation. To achieve greater genetic diversity and thus higher genetic variation of germplasm pools currently available at PhilRice, there is a need to infuse more variation from other rice subpopulations like the japonica group as well as rice's wild progenitor, Oryza rufipogon. The study aims to develop indica hybrid rice parent lines with japonica and wild rice (Oryza rufipogon) introgressions.

Highlights:

- BC1F1 seeds from crosses between hybrid parental lines (HPLs) and japonicas and wild rice derivatives produced in 2011 wet season (WS) were planted and backcrossed to HPLs in 2012 dry season (DS) generating 23 F1 crosses. During 2013DS, a total of 36 BC2 entries (23 F1 and 13 male parents) were evaluated in the Testcross Nursery (TCN). Of these, three performed better than the check variety Mestiso 1 with a yield ranging from 239.05 g – 467 g (Table 5).

- Because of the weedy appearance of the BC2F1 populations, which is a cross between hybrid parental lines and wild rice, further backcrossing was done and 39 F1 crosses were produced. A sum of 70 BC3 test entries (39 F1 and 31 male parents) were assessed, and 21 were more superior over the check variety Mestiso 1 (Table 6).

Table 5. Top performing BC2 entries, PhilRice CES, 2013DS.

Code	Identity	Plant ht (cm)	# of tiller	Panicle length (cm)	1000 grain wt (g)	yield (g)*
	M1			26.42	26	210.5
F1						
TCN 1273	IR68897A/BC2-14-4	101.6	16	23.24	26.24	467
TCN 1261	IR68897A/BC2-5-1	118.2	22	23.81	22.81	277.01
Parent						
TCN 1278	BC2-25-1	111.4	15	27.37	26.51	239.05

**based from 5 hills*

Table 6. Top performing BC3 entries, PhilRice CES, 2013DS.

Code	Identity	Plant ht (cm)	# of tiller	Panicle length (cm)	1000 grain wt (g)	yield (g)*
	M1			26.42	26	210.5
F1						
TCN 1299	IR58025A/BC3-8-2	113	22	25.40	22.65	280
TCN 1359	IR58025A/BC3-21-2	106	21	27.85	27.54	245.15
TCN 1358	IR58025A/BC3-21-1	112	18	28.88	27.54	234.83
TCN 1352	IR58025A/BC3-4-1	109	19	26.52	26.33	220
TCN 1307	IR58025A/BC3-12-1	114	16	26.79	28.66	215
Parents						
TCN 1342	BC3-24-2	110	19	27.26	29.77	329
TCN 1296	BC3-7-3	108	17	27.24	22.38	314
TCN 1318	BC3-16-1	100	23	26.70	27.68	303
TCN 1310	BC3-12-3	108	19	26.64	27.26	301.54
TCN 1356	BC3-11-1	106	23	26.41	24.15	294
TCN 1317	BC3-15-1	104	15	24.35	26.29	284.53
TCN 1338	BC3-23-4	107	16	27.39	26.39	282
TCN 1350	BC3-25-1	115	18	27.25	25.31	253
TCN 1348	BC3-24-4	112	22	22.99	27.2	250
TCN 1324	BC3-20-1	118	16	23.90	26.86	238.22
TCN 1302	BC3-10-2	109	16	25.25	26.29	234.41
TCN 1332	BC3-23-1	108	19	26.30	27.1	233
TCN 1326	BC3-20-2	104	17	26.19	26.58	229.96
TCN 1328	BC3-20-3	110	16	27.44	26.45	229
TCN 1330	BC3-20-4	113	17	28.29	26.87	217
TCN 1294	BC3-7-2	102	18	27.10	25.1	216.2

Figure 3. Selected entries in the Testcross Nursery, PhilRice CES 2013DS.

Finding durable and novel blast resistance genes effective against Philippine's Magnaporthe grisea pathogen population

LM Perez,TE Mananghaya, T Masangcay, JP Rillon, MS Duca and TF Padolina

Probably, the main reasons why rice blast disease is difficult to control are: the population structure of the fungus Magnaporthe grisea is very diverse in terms of pathotypic race and the pathogen is very well capable of producing new ones. Unfortunately, there is no or limited information on the characteristics of its population. When gained, this could give direction as to what genes and where a gene should be deployed.

The goal of this study is to establish information on the structure of rice blast pathogen population in major rice growing areas in the Philippines. From this knowledge, effective resistance genes against the population will be identified. Furthermore, this study also aims to discover novel and durable resistance genes from traditional varieties as well as released varieties.

Highlights:

- Forty six differential varieties along with two resistant and one susceptible control were established in Brgy. Quezon, San Carlos City, Negros Occidental for on- farm screening sites for blast resistance evaluation. During vegetative stage, disease development of leaf blast incidence was not observed in most of established materials except on CO39, the susceptible control. Panicleblast was noted in most of test materials except in SHZ-2, IRBLz-Fu and IRBL7-M. The yield of 32 monogenic lines (LTH) ranged from 0.52 to 3.74 tons/ha while 21 CO39 NILs (near isogenic lines) were from 1.73 to 4.17 tons/ha.

- A total of 78 test entries consisting of monogenic lines, CO 39 NILs (near isogenic lines) and advanced breeding materials of blast were introduced to seven NCT sites for blast screening evaluation in 2013 dry season. Among seven NCT locations, only PhilRice-CES submitted the reports on the blast resistance evaluation. Based on the results, IR65482-4-136-2-2 containing Pi40, known resistant to rice blast exhibited intermediate reaction while SHZ-2 was found resistant to the disease (Table 7).

- Establishment of materials up to maturity on Benguet State University was decided to stop because the blast materials didn't produce seeds because of cold stress. The construction of blast nursery was started at September 2013. Three plots with measurement of 1m x 9m were made; this is to accommodate more populations for blast resistance evaluation of potential parents and advanced lines with blast resistance genes.

- Sixty blast materials composed of 32 monogenic lines (LTH), 5 CO39 NILs (near isogenic lines), 12 advanced breeding lines with blast resistance (F5), 11 advanced lines of NSIC Rc160Sub1, 4 BC2F3 lines of PSB Rc82 Sub1, 3 susceptible controls and 2 blast resistant checks were sent to seven NCT locations for 2013 wet season.

- Initial evaluation for blast resistance was conducted in NOMIARC (Northern Mindanao Integrated Agriculture Research Center) in Malaybalay, Bukidnon. Sixty blast materials composed of 32 monogenic lines (LTH), 5 CO39 NILs (near isogenic lines), 12 advanced breeding lines with blast resistance (F5), 11 advanced lines of NSIC Rc160 Sub1, 4 BC2F3 lines of PSB Rc82 Sub1, 3 susceptible controls and 2 blast resistant checks were established. This was conducted to measure the blast incidence pressure in Northern Mindanao, specifically in Bukidnon, where geographical location is in middle elevation area. Ms. Lucille Minguez assisted us to the experimental area and we found out that susceptible check, CO39, suffered heavily (Figure 4) from leaf blast and panicle blast and even the differential varieties shown susceptibility to the pathogen. Thus, concluded us that the climate condition is conducive for the pathogen for disease development Letter of Agreement were made for PhilRice-DA-NOMIARC collaboration and the study will be formally started in 2014 dry season.

Table 7. Disease reaction of Pi40, SHZ-2 and IR50 in blast nursery, PhilRice CES 2013 DS.

			Leaf blast lesion score					
Entry Name	Classification	*Pi gene*	Rep I	Rep II	Rep III	Average	Rate	
Pi40	IR65482-4-136-2-2	*Pi40*	3	5	3	4	I	
Pi40	IR65482-4-136-2-2	*Pi40*	3	3	3	3	R	
Pi40	IR65482-4-136-2-2	*Pi40*	4	3	4	4	I	T
Pi40	IR65482-4-136-2-3	*Pi40*	4	4	5	4	I	
Pi40	IR65482-4-136-2-2	*Pi40*	3	3	3	3	R	
SHZ-2	Resistant Check	*QTL*	1	3	3	2	R	
SHZ-2	Resistant Check	*QTL*	3	1	3	2	R	
SHZ-2	Resistant Check	*QTL*	1	3	3	2	R	R
SHZ-2	Resistant Check	*QTL*	1	3	3	2	R	
SHZ-2	Resistant Check	*QTL*	3	3	3	3	R	
IR50	Susceptible Check		9	9	9	9	S	
IR50	Susceptible Check		9	9	9	9	S	S
IR50	Susceptible Check		9	9	9	9	S	
IR50	Susceptible Check		9	9	9	9	S	

Figure 4. Disease reaction of susceptible check, CO39 in rice blast at DA-NOMIARC in 2013WS.

Elucidating the current physical and milling quality traits in support to breeding
EH Bandonill

In order to facilitate and fast-track grain quality screening with improved accuracy and delivery, this study tried to develop low-cost and efficient methods for screening crack resistance and grain hardness and for determining crack and chalkiness of rice, as well as generate information on factors affecting rice quality. Physical attributes of milled rice determines its price in the market. High amount of broken grains decreases the value of milled rice. Chalkiness, grain cracking due to water absorption, and moisture content of harvested paddy are the known factors which affect head rice recovery. Increasing head rice recovery will increase the value of milled rice and availability of quality table rice. Thus, development of screening methods for crack resistance and grain hardness is also essential. Moreover, consumers prefer rice that is translucent and not chalky. Therefore, various environmental factors (i.e temperature, soil and field water pH, elevation) affecting chalkiness of rice have to be documented. Meanwhile, evaluation of chalkiness in milled rice through manual or human classification is laborious and requires skilled or trained individual with accurate and consistent assessment. PhilRice started to develop its own software that can analyze the chalkiness of milled rice using acquired digital images. This was after finding out that the predicting value of the Rice Quality Classification Software (RQCS) developed by Philippine Center for Postharvest Development and Mechanization (PhilMech) then modified to PhilMech Grain Quality Analysis Software (PGQAS), was not enough to classify chalkiness of various milled rice obtained from the Rice Varietial Improvement Group (RVIG) and other breeding materials.

A. Development of screening methods for crack resistance and grain hardness

BO Juliano, APP Tuaño, DN Monteroso, AR Agarin, AD Peñaloza and MG Lansin

Collaborators: TF Padolina, LM Perez and R Tabien

- Rough rice soaking method was employed in screening recently released varieties and F1 population from PSB Rc52 and Rc38 cross. Twelve - 14 samples (unreplicated) can be screened per day considering an overnight simultaneous air-drying of 1 batch. Sample size required is 10g rough rice.

- Brown rice exposure method (humidity chamber method) was refined. Validation is on-going using the same set of samples used in rough rice soaking method. Using 1 hr exposure and 4 hrs air-drying, 12-14 samples per day can be analyzed depending on the capacity of the oven. Validation will be completed by end of 2013.

- Five cultivars were selected as potential parentals for crack resistance breeding (mainly using the brown rice exposure method) and molecular studies shall be further characterized. These include NSIC Rc160, PSB Rc52, Rc38, Burdagol and IR42.

- A 0.86-0.97 correlation among unstressed and stressed head rice yield data was generated.

B. Evaluation of rice milling potential and chalkiness as influenced by various environmental factors

EH Bandonill, TF Padolina, GG Corpuz, OC Soco

Collaborators: MJ Du, WC Malayao (Bohol) and HCascolan (PSU)

- In 2012 wet season, Maligaya samples had the highest milled rice (69.9-72.1%) and head rice (41.7-61.2%) recoveries, followed by Pangasinan and lastly by Bohol samples (Table 8).

- Temperature (T) and relative humidity (RH) during ripening of rice grains were higher in Maligaya than in Bohol (Table 9), which may have favored the higher chalkiness of Maligaya samples (Table 10).

- In 2013 dry season, Pangasinan-Transplanted (TP) samples had higher brown rice (75.7-79.5%), milled rice (65.5-71.3%), and head rice (26.4-46.1%) recoveries than Pangasinan-Direct Seeded (DS) samples (Table 11).

- Similar to previous results, the 2013 temperature (T) and relative humidity (RH) particularly during ripening of rice grains in Maligaya were higher during wet season (September to October) than during dry season (February to March) (Table 12).

Table 8. Milling potential of check varieties planted in different locations during 2012 WS.

Check Variety	% Brown Rice						% Milled Rice						% Head Rice					
	Pangasinan		Maligaya		Bohol		Pangasinan		Maligaya		Bohol		Pangasinan		Maligaya		Bohol	
PSB Rc82	77.1	F	77.4	F	68.3	P	69.5	G1	71.3	Pr	59.3	G3	46.0	G2	50.1	G1	51.3	G1
NSIC Rc224	76.2	F	77.6	F	70.0	P	68.6	G1	72.1	Pr	61.4	G2	49.5	G1	41.7	G2	53.7	G1
NSIC Rc222	75.5	F	76.9	F	67.6	P	66.5	G1	71.4	Pr	57.4	G3	40.0	G2	59.2	Pr	52.6	G1
PSB Rc18	72.0	P	75.9	F	63.4	P	60.9	G2	69.9	G1	52.0	G3	45.5	G2	61.2	Pr	43.0	G2

Table 9. Temperature and relative humidity of the different locations where the check varieties were planted during 2012 WS.

Check Variety	Temperature (°C)		Relative Humidity (%)	
	Maligaya	Bohol	Maligaya	Bohol
September	22.8-32.5	24.5-27.0	70.0-94.0	41.5-88.0
October	22.3-34.2	23.0-26.5	49.0-93.0	65.0-87.0

Table 10. Physical attributes of check varieties planted in different locations during 2012 WS.

Check Variety	% Chalky Grains						% Immature Grains					
	Pangasinan		Maligaya		Bohol		Pangasinan		Maligaya		Bohol	
PSB Rc82	22.1	aa	16.5	aa	4.2	G1	14.5	G3	5.1	G2	4.3	G1
NSIC Rc224	25.9	aa	20.0	aa	5.6	G2	8.7	G2	8.4	G2	4.3	G1
NSIC Rc222	22.6	aa	3.1	G1	5.5	G2	10.6	G3	3.6	G1	4.2	G1
PSB Rc18	11.4	G3	14.0	G3	0.4	Pr	14.0	G3	5.6	G2	5.4	G2

Table 11. Milling potential of check varieties planted in PSU Pangasinan during the 2013 DS.

Check Variety	% Brown Rice				% Milled Rice				% Head Rice			
	Pangasinan DS		Pangasinan TP		Pangasinan DS		Pangasinan TP		Pangasinan DS		Pangasinan TP	
PSB Rc82	74.1	P	79.5	F	63.0	G2	71.3	Pr	15.7	aa	35.1	G3
NSIC Rc224	72.8	P	77.4	F	62.0	G2	69.4	G1	26.8	aa	46.1	G2
NSIC Rc222	74.9	P	78.8	F	61.5	G2	65.5	G1	23.7	aa	26.4	aa
PSB Rc18	71.5	P	75.7	F	62.8	G2	66.5	G1	40.0	G2	26.5	aa

Table 12. Temperature and relative humidity in PhilRice CES during the 2013 DS.

Check Variety	Temperature (°C)		Relative Humidity (%)	
	Range	Mean	Range	Mean
February	23.6-28.6	25.9	74.5-89.5	80.1
March	23.6-28.6	26.6	75.9-89.5	80.8
September	24.5-28.3	26.3	82.3-88.9	86.2
October	25.2-28.3	26.3	82.3-88.9	84.9

Temperature (T) and relative humidity (RH) influenced the chalk formation of rice samples during grain ripening. Maligaya samples which had higher temperature (T) and relative humidity (RH) had higher chalkiness than in Bohol samples with relatively lower T and RH.

C. Development of PhilRice software for detecting physical attributes for breeding quality rice

IG Pacada, EH Bandonill, OC Agustin, A Tuates, TF Padolina, APP Tuaño, and BO Juliano

- Developed graphical interface for PhilRice software (Figure 5). Features of this software include image processing, feature extraction, model manager, and dataset management.

- Extracted blob images of training samples from matured and immature and translucent grains. Blob extraction is shown in Figure 6.

Figure 5. Screenshot of PhilRice Grain Classifier (PGC).

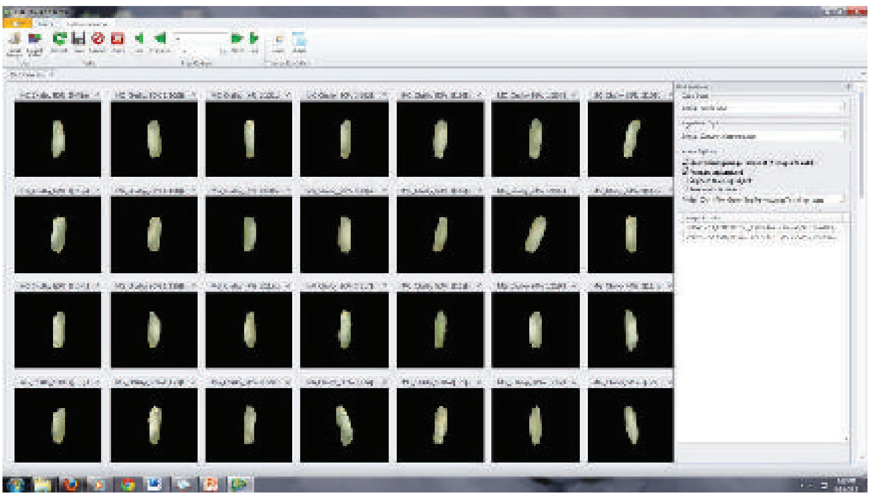

Figure 6. Screenshot of blob extraction under the feature extraction application.

Optimization of a rapid screening method against sheath blight (Rhizoctonia solani) in rice and development of sheath blight tolerant breeding lines

AA Alfonso, RT Miranda, and ES Avellanoza

Screening rice breeding materials against sheath blight in rice caused by Rhizoctonia solani is done under field conditions most of the time. The most widely accepted method of evaluation is inoculation of densely planted field plots with Rhizoctonia solani, allowing it to grow over time and rate the plots for severity of disease symptoms. Such process entails longer screening time (1 full season per screening), labor intensive, costly and requires more seeds.

A new method of screening the fungal disease was originally conducted in Bangladesh. Formally known as the ‘micro-chamber’ method (moisture is being trapped by the soda bottles during incubation period, allowing to create a humid ‘micro-environment’ for the seedling) see fig. 7, this process requires less seed, less labor, less screening costs and shorter plant-growth time needed to come up with a result. It is also conducted under controlled screenhouse conditions, thus freeing researchers to the restriction on the timing of planting in the field every season.

Validation and improvement/development of the ‘micro-chamber’ method of screening against sheath blight under Philippine screenhouse condition will make it easier for the breeders to fast-track the development of elite lines with resistance/tolerance to the fungal disease. With this new method, it will allow screening for early generation breeding material+ls which usually have few seeds.

Moreover, an existing method to rapidly screen materials against sheath blight will certainly speed up breeding efforts for the development of lines resistant to the disease. The identification of potential donors for the disease can be achieved in a shorter period of time as well as screening of breeding materials during hybridization.

Highlights:

- Of the 28 breeding lines evaluated for sheath blight resistance 12 were selected and advanced to ON and PYT evaluation for 2013 WS.

- For 2013 DS screening under field condition, only one out of 35 entries was selected with an intermediate reaction and the rest with susceptible rating including five reported moderately resistant cultivars.

- Using five reported moderately resistant (MR), two susceptible checks and one recurrent parent, we compared micro-chamber method (Fig. 7) and existing protocol (induced method in the field) in evaluating breeding lines for sheath blight resistance and validation of the effectiveness of using micro-chamber method in ShB screening. The 2013 DS result (Table 13.) for the comparison of the two methods shows that of the five MR checks, four were rated intermediate using micro-chamber method but were all susceptible in field screening. Jasmine 85 supposedly a resistant check and recurrent parent, NSIC Rc138 were rated susceptible in both method. Susceptible check, TN1, showed an intermediate reaction in micro-chamber method but susceptible in the field. Out of eight test entries, only three entries showed consistent reaction in both screening method, with this result further validation will be conducted in the next season.

Table 13. Disease reaction rating of reported moderately resistant lines, recurrent parents and susceptible check using micro-chamber method (screenhouse) and induced method in the field.

13DS Index No.	13DS Field Code	13DS MC-Screening Code	DESIGNATION	ShB Infection Rating				ShB Rating (MC)	ShB Rating (Field)
				RI	RII	RIII	AVE		
1	13DS-ShB-1	13DS-ShBM-1	Jasmine 85	7	7	5	7	S	S
2	13DS-ShB-2	13DS-ShBM-2	Lemont	6	9	6	7	S	S
3	13DS-ShB-3	13DS-ShBM-3	Katy	6	5	6	5	I	S
4	13DS-ShB-4	13DS-ShBM-4	Te-Qing	7	7	5	6	I	S
5	13DS-ShB-5	13DS-ShBM-5	LSBR 5	5	6	8	6	I	S
6	13DS-ShB-6	13DS-ShBM-6	LSBR 33	6	5	6	6	I	S
7	13DS-ShB-7	13DS-ShBM-7	NSIC Rc138	7	6	7	7	S	S
36	13DS-ShB-36	13DS-ShBM-36	TN1	6	6	6	6	I	S

Figure 7. Microchamber setup. Twenty one days after sowing, the seedlings were inoculated using a mycelial disk as inoculum carrier and then covered with 1.5-liter plastic soda bottle.

Figure 8. Field inoculation set-up (induced method). Inoculation was done 40-55 DAT (A) and was evaluated for infection rating at 14 DAI (B) based on Resistant and susceptible reaction (C). Evaluation of infection was done by crop protection division (D).

Prospects of multiline variety mixture for disease response
TF Padolina and AQC Sabanal

Plant breeding has achieved high crop yields through hybridization and selection of superior plants. These superior types are often grown in monocultures where each plant is genetically identical to its neighbor. Monocultures provide high selection pressure on disease pathogens to evolve and overcome the plants résistance genes. Plant diseases can prevent a crop from achieving its yield potential, and the cost of disease and its prevention can dramatically affect the economics of crop production. If genetic uniformity through monoculture makes a crop more vulnerable to disease, then one potential, low cost and sustainable approach of suppressing disease is to increase the genetic diversity of the crop. A simple way to enhance genetic diversity is to mix the seed of cultivars (i.e. plant genotypes) that vary in their susceptibility to specific pathogens but are similar in phenotype. This method ensures genetic diversification with the advantage that it can be used in addition to any other form of disease control.

The study aims to assess the effects of cultivar mixtures using Philippines rice varieties in limiting the development of diseases under field condition. And also, determine and compare the agronomic gain of multiline variety mixture versus monoculture rice variety.

Highlights:

- Multi-line variety mixtures were successfully established during the wet seasons of 2013 using the following combinations and randomized layout (Figure 9):

  Early maturing group
  Monoculture: IR64 and PSB Rc82
  Mixed: IR64 and PSB Rc82
  Interplanting: IR64 and PSB Rc82

  Medium Maturing Group
  Monoculture: NSIC Rc134 and PSB Rc10
  Mixed: NSIC Rc134 and PSB Rc10
  Interplanting: NSIC Rc134 and PSB Rc10

  Late Maturing Group
  Monoculture: NSIC Rc134 and PSB Rc10
  Mixed: NSIC Rc134 and PSB Rc10
  Interplanting: NSIC Rc122 and NSIC Rc128

- Harvest index and yield component data was gathered to represent the yielding ability of each entry since typhoon Santi caused lodging in some entries (Table 14).

- Generally, variety mixture showed good performances by having lower harvest indices in comparison with the monoculture. Complementarity between the two paired varieties can be seen with the values of interplanting or mixed. In terms of mixing the varieties, interplanting showed better results for wearly and medium maturing varieties.

- In the early maturing variety combination, interplantng showed better in harvest index compared to the monocultered varieties. Complimentary effects can be seen with the variety mixture in comparison with the monoculture. The higher yielding PSB Rc82 produced an average yield with IR64 in the variety mixtures.

- Similarly with the medium maturing variety mixture, Interplanted NSIC Rc134 with PSB Rc10 even surpassed performances by showing higher harvest index than the mono cultured.

- For late maturing entries, mixture by seed produced lower harvest index compared to the monocultured and inter planted varieties.

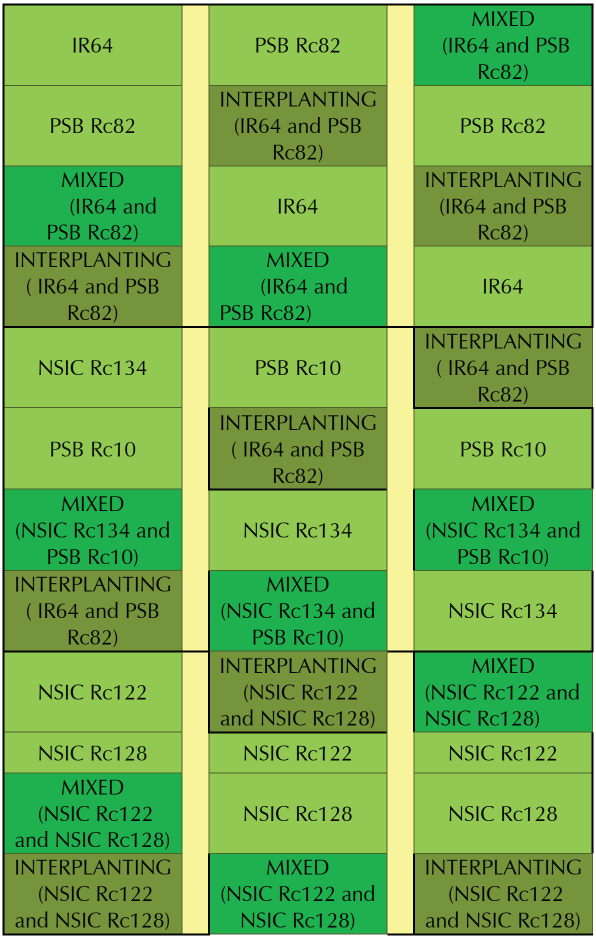

Figure 9. Field lay out of early, medium and late maturing multi-line variety mixtures

Table 14. Harvest Index of multiline entries 2013 wets season.

ENTRY	TOTAL PLANT WEIGHT			GRAIN WEIGHT			HARVEST INDEX (%)		
EARLY MATURING	REP1	REP2	REP3	REP1	REP2	REP3	REP1	REP2	REP3
IR64	52.31	45.89	49.97	21.78	18.49	20.94	41.6	40.3	41.9
PSB Rc82	55.20	52.66	43.86	22.80	20.15	16.83	41.3	38.3	38.4
INTERPLANTING (IR64 & PSB Rc82)	59.15	42.29	47.71	23.00	15.12	19.04	38.9	35.8	39.9
MIXED (IR64 & PSB Rc82)	48.61	51.99	45.81	20.81	21.68	16.65	42.8	41.7	36.3
MEDIUM MATURING									
NSIC Rc134	56.14	69.93	48.93	23.69	25.04	22.35	42.2	35.8	45.7
PSB Rc10	45.27	47.71	45.77	23.30	25.90	24.87	51.5	54.3	54.3
INTERPLANTING (NSIC Rc134 & PSB Rc10)	45.43	62.01	41.52	19.45	20.18	16.59	42.8	32.5	40.0
MIXED (PSB Rc134 & PSB Rc10)	63.97	50.20	50.71	27.15	22.62	25.25	42.4	45.1	49.8
LATE MATURING									
NSIC Rc122	50.40	45.01	43.39	20.24	18.86	18.53	40.2	41.9	42.7
NSIC Rc128	53.12	49.31	57.12	24.55	19.54	23.24	46.2	39.6	40.7
INTERPLANTING (NSIC Rc122 & NSIC Rc128)	47.81	45.28	52.26	23.27	17.92	21.08	48.7	39.6	40.3
MIXED (NSIC Rc122 & NSIC Rc128)	51.43	56.41	50.87	20.11	23.73	20.88	39.1	42.1	41.0

Evaluation of donor germplasm

AC Sabanal, LA Pautin, EC Arocena and TF Padolina

Wide variability is the cornerstone of successful varietal improvement programs. Hence, collection of germplasm with diverse genetic make-up is necessary. The use of parental with diverse genetic make-up will simultaneously expands the genetic base for selection and opportunity to select novel and/or superior characteristics of agronomic importance. The crossing block is the assemblage of diverse parents for hybridization usually grown in the field. Parentals to be used in crosses will be selected from germplasm pool of elite lines, introductions, traditional varieties, mutant lines and derivatives of wide hybrids. The study aims to evaluate, characterize, and select donor parents with traits relevant to breeding program. Crosses involving diverse germplasm with high yield, pest resistance and good grain quality will also be generated.

Highlights:

- During the 2013 wet season, continued diversification of the crosses was done through conventional breeding. 448 potential donors were assembled in two staggered replicates in the crossing block.

- 67 donors were characterized based on yield component traits. These donor germplasm were composed of varieties, traditional varieties, elite lines and collections from Turkey and China.

- 169 donor parents were used in the hybridization of 80 new paired crosses by the irrigated lowland breeding team. The types of crosses used were mostly single crosses (99%). Three-way cross (1%) was also done to improve the F1 generation. These crosses varied in terms of its breeding objective (Figure 10.) specifically targeting the improvement of yield, plant type, grain size, fertility, bacterial leaf blight resistance and blast resistance. Aside from this, the crossing block also provided donor germplasm to other breeding teams.

- The diversity of materials in the crossing block was also studied by the Germplasm Resource Division (GRD) through morphological evaluation, molecular diversity analysis and grain quality evaluation. Results showed that, the average diversity index (Shannon Weaver Diversity) based on 12 agro morphological traits is 0.69. There is low diversity (0.15) in the maturity of the germplasm. Initial molecular data showed an average of 0.14 gene diversity of the materials. In terms of bacterial blight resistance, 97% of the materials carry Xa4 gene.

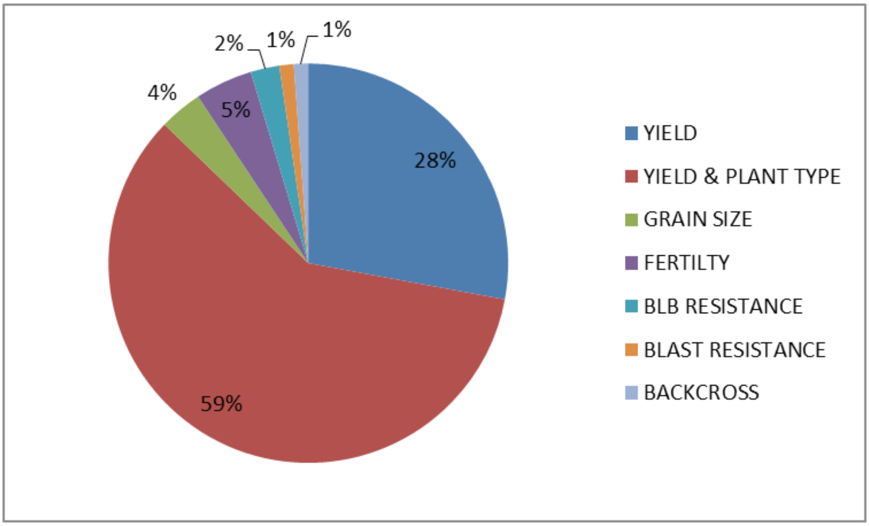

Figure 10. Classification of new crosses generated based on breeding objectives, 2013 WS.

II. National Cooperative Testing (NCT)

TF Padolina, JF Parinas and J Dancel

The National Cooperative Testing (NCT) is a nationwide coordinated trial for rice varietal improvement. It is a continuation of the concerned agencies efforts to develop new and improved rice varieties for the Philippines. The objective is to determine the relative merits of promising lines in yield, rice quality, and resistance/tolerance to various stresses in the different eco-geographical/agro-ecological regions of the country.

The NCT is implemented by the Rice Technical Working Group (RTWG). The RTWG is a technical working group of the National Seed Industry Council (NSIC) mandated under the Seed Industry Development Act of 1992 (RA 7308) to: (1) conduct field testing and performance evaluation of promising rice lines and hybrids, and nominate to the NSIC new and improved rice varieties for cultivation; (2) formulate procedures for varietal evaluation and identification; and (3) perform other related functions that may be assigned to it by the Executive Director of NSIC.

Highlights:

- The Rice Technical Working Group (RTWG) has conducted the Rice Varietal Improvement Group (NCT implementers) and 2 special RTWG meetings where important issues and entry deliberations/decisions were made. The RTWG special meeting held in PhilRice CES on April 17, 2013 has deliberated a total of 29 test entries and only 11 passed the standards. While in the RVIG meeting held in Naga City on May 23-24, 2013, there were 47 promising entries in the various NCT trial s and 9 were recommended as potential varieties (Table 19). Upon recommendation to the Technical and Council Secretariat on October 18, 2013, respectively, 22 new varieties were approved for commercial cultivation in 2013. Consolidated summary performance of these varieties with their NSIC registry number and popular names is presented in Table 15. Resistance to biotic stresses and grain quality are summarized in Tables 16 to 17.

- In another RTWG special meeting on November 27-28, 2013 held in Manila, 33 entries were again deliberated. Of these, 9 hybrids passed the standards, 5 belong to Syngenta, 1 each from Bioseed and Advanta and 1 each from PhilRice and IRRI (Table 18). There were also 5 inbreds from the irrigated lowland and 2 from the saline group of entries. The meeting also discussed the status of the NCT Manual and some administrative matters on collection of testing fees by the Council.

- In Table 19, 10 out of 16 promising lines from the irrigated lowland Phase 1 were advanced to Multi-Adaptation trials for further tests. One entry, HHZ8-SAL6-SAL3-Y2 will be transferred to saline and rainfed NCT for further evaluation. It was dropped from the irrigated trial owing to low yield performance.

Table 15. Summary of NSIC approved rice varieties and corresponding agronomic traits, 2013.

OFFICIAL NSIC REGISTRY NUMBER	LOCAL NAME	LINE DESIGNATION	BREEDING INSTITUTION	AGRONOMIC CHARACTERISTICS					
					Ave. Yield (t/ha)	Max. Yield (t/ha)	Maturity (DAS)	Height (cm)	Tillers #
IRRIGATED LOWLAND (inbred)									
NSIC 2013 Rc308	Tubigan 26	PR35766-B-24-3	PhilRice	TPR	5.8	10.9	111	99	15
				DWSR	5.5	8.0	105	94	294
IRRIGATED LOWLAND (Special rice)									
NSIC 2013 Rc342SR	Mabango 4	PR37299-31-69-16-2-1-2 (A)	PhilRice		4.3	7.3	114	103	15
NSIC 2013 Rc344SR	Mabango 5	IR04A285 (A)	IRRI		5.3	8.2	118	102	18
IRRIGATED LOWLAND (hybrid)									
NSIC 2013 Rc310H	Mestiso 44	H6129	Bayer		5.7	11.5	112	103	13
NSIC 2013 Rc312H	Mestiso 45	INH97158	Bayer		5.7	9.8	115	102	14
NSIC 2013 Rc314H	Mestiso 46	INH10001	Bayer		5.9	11.3	118	110	14
NSIC 2013 Rc316H	Mestiso 47	PR36559H	PhilRice		6.0	11.2	110	99	14
NSIC 2013 Rc318H	Mestiso 48	PR35664H	PhilRice		6.2	12.3	110	109	13
NSIC 2013 Rc320H	Mestiso 49	PR36444H	PhilRice		5.8	10.7	108	99	14
NSIC 2013 Rc322H	Mestiso 50	P2010-31	Pioneer		5.8	10.2	115	109	13
NSIC 2013 Rc350H	Mestiso 51	SW 82	Seedworks		6.2	10.4	116	112	13
SALINE									
NSIC 2013 Rc324	Salinas 10	PR31607-2-B-B-B-B	PhilRice		2.4	6.0	113	91	13
NSIC 2013 Rc326	Salinas 11	IR84084-B-B-1-1	IRRI		2.4	4.9	115	91	13
NSIC 2013 Rc328	Salinas 12	IR62700-2B-9-2-3	IRRI		2.4	5.7	113	95	14
NSIC 2013 Rc330	Salinas 13	PR37435-30-1	PhilRice		2.7	5.6	114	93	14
NSIC 2013 Rc332	Salinas 14	PR38566-WAGWAG V9-3-2-15-2	PhilRice		2.3	5.2	113	88	14
NSIC 2013 Rc334	Salinas 15	IR83410-6-B-4-1-1-2	IRRI		2.5	4.7	115	95	14
NSIC 2013 Rc336	Salinas 16	IR84095-AJY3-8-SD01-B	IRRI		3.0	5.9	115	91	13
NSIC 2013 Rc338	Salinas 17	PR30665-1B-1-B-B-Cg	PhilRice		2.5	5.1	114	94	13
NSIC 2013 Rc340	Salinas 18	IR84096-AY4-2-SD04-B	IRRI		2.5	4.8	113	93	13
Rainfed Lowland Drought-prone									
NSIC 2013 Rc346	Sahod-ulan 11	PR34350-4-POKKALI-24-M5R-10	PhilRice						
NSIC 2013 Rc348	Sahod-ulan 12	IR81047-B-106-2-4	IRRI						

NSIC = National Seed Industry Council; SR = Special Rice; TPR = Transplanted Rice; DWSR = Direct Wet Seeded Rice

Table 16a. Summary of disease reactions of NSIC approved rice varieties, 2013.

L NSIC REGISTRY NUMBER	BLAST (Induced)						BACTERIAL LEAF BLIGHT (Induced)						SHEATH BLIGHT (Induced)						TUNGRO (Induced)		TUNGRO (Modified)		
	PhilRice CES	PhilRice Isabela	PhilRice Midsayap	UPLB	DA CVIARC	VSU	PhilRice CES	PhilRice Midsayap	PhilRice Isabela	UPLB	VSU	WES-VIARC	PhilRice CES	PhilRice Midsayap	PhilRice Isabela	UPLB	VSU	WES-VIARC	PhilRice CES	UPLB	IRRI	PhilRice CES	PhilRice Midsayap
' lowland (inbred)																							
13 Rc308	S	I	-	S	-	I	I	I	I	I	I	S	S	I	-	S	I	S	S	S	S	-	S
ED LOWLAND (Special rice)																							
13 Rc342SR	S	I	R	S	-	S	I	I	I	I	S	S	S	I	I	S	I	S	S	S	S	-	S
13 Rc344SR	S	I	R	S	-	I	S	I	I	I	S	I	S	I	I	I	I	I	S	S	I	-	S
ED LOWLAND (hybrid)																							
13 Rc310H	I	I	I	I	-	I	S	I	S	I	I	I	S	I	-	I	I	I	S	S	S	-	S
13 Rc312H	I	I	R	I	-	I	I	S	I	I	S	S	S	I	S	I	S	I	S	S	S	-	S
13 Rc314H	I	I	R	I	-	S	I	R	I	I	I	I	S	I	R	I	S	I	S	S	S	-	S
13 Rc316H	I	I	I	I	-	S	S	I	I	I	S	S	S	I	R	S	I	I	S	S	S	-	S
13 Rc318H	I	I	I	R	-	I	S	I	S	I	S	S	S	S	-	I	I	S	S	S	S	-	S
13 Rc320H	S	I	I	I	-	S	S	I	S	S	S	S	S	I	S	S	S	S	S	S	S	-	S
13 Rc322H	S	I	I	R	-	S	I	I	I	I	S	I	S	I	R	I	S	I	S	S	S	-	S
) LOWLAND																							
13 Rc346	S	I	I	I	R	I	S	I	S	I	I	S	S	I	R	I	I	S	S	S	S	-	S
13 Rc348	S	R	I	I	S	S	S	I	S	I	S	I	S	I	R	S	I	I	S	S	R	-	I
conducted at PhilRice CES only)																							
13 Rc324	S					S							S						S				
13 Rc326	S					I							S						S				
13 Rc328	S					I							S						S				
13 Rc330	S					I							I						S				
13 Rc332	S					I							S						S				
13 Rc334	I					I							S						S				
13 Rc336	S					I							S						S				
13 Rc338	S					I							S						S				
13 Rc340	S					S							S						S				

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Table 16b. Summary of reactions to insect pests of NSIC approved rice varieties, 2013.

OFFICIAL NSIC	DEADHEARTS			WHITEHEADS							BPH	GLH	YSB
REGISTRY NUMBER	(WSB)	(YSB)		(WSB)		(YSB)							
	PhilRice	PhilRice	Phil Rice	PhilRice	PhilRice	Phil Rice	Phil Rice	UPLB	BIARC	VSU			
	Midsayap	Midsayap	Isabela	Agusan	Midsayap	CES	Isabela						
Irrigated lowland (inbred)													
NSIC 2013 Rc308	-	-	-	MR	-	I	-	R	-	-	MR	I	I
IRRIGATED LOWLAND (Special rice)													
NSIC 2013 Rc342SR	-	-	-	I	-	I	-	-	-	MR	I	MR	I
NSIC 2013 Rc344SR	-	-	-	MS	-	MS	-	-	-	I	MR	I	I
IRRIGATED LOWLAND (hybrid)													
NSIC 2013 Rc310H	-	-	-	MS	-	MS	MS	-	R	R	I	I	I
NSIC 2013 Rc312H	-	-	-	MS	-	I	MS	-	R	MR	MR	I	MS
NSIC 2013 Rc314H	-	-	-	S	-	I	R	-	R	R	I	MS	I
NSIC 2013 Rc316H	-	-	-	S	-	MS	I	-	R	R	MR	MR	MS
NSIC 2013 Rc318H	MR	-	R	S	-	MS	-	MR	R	-	I	MR	I
NSIC 2013 Rc320H	-	-	-	R	-	S	S	-	R	R	MS	MR	I
NSIC 2013 Rc322H	-	-	-	S	-	MS	MS	-	MR	MR	I	I	MS
RAINFED LOWLAND													
NSIC 2013 Rc346	-	-	-	R	-	MR	-	-	-	-	I	I	-
NSIC 2013 Rc348	-	-	-	R	-	MR	-	-	-	-	I	I	-
SALINE (conducted at PhilRice CES only)													
NSIC 2013 Rc324						MS					I	MR	MS
NSIC 2013 Rc326						S					I	MR	MS
NSIC 2013 Rc328						MS					I	MR	MS
NSIC 2013 Rc330						I					I	MR	MS
NSIC 2013 Rc332						MS					I	MR	MS
NSIC 2013 Rc334						S					I	I	I
NSIC 2013 Rc336						S					I	MR	MS
NSIC 2013 Rc338						MS					I	MR	MS
NSIC 2013 Rc340						S					I	MR	MS

R = Resistant
MR = Moderately Resistant
I = Intermediate
MS = Moderately Susceptible
S = Susceptible
- no trial

WSB = White Stemborer
YSB = Yellow Stemborer

Table 17. Summary of grain quality characteristics of NSIC approved rice varieties, 2013.

OFFICIAL NSIC REGISTRY NUMBER	Physico-chemical Characteristics			Milling Potentials				Physical Attributes			% Acceptability	
	% Amylose	% Protein	G.T. Score	% Brown Rice	% Milling Recovery	% Head Rice	% Chalky Grains	% Immature Grains	Grain Length/ Size	Grain Shape	Cooked	Raw
IRRIGATED LOWLAND (inbred)												
NSIC 2013 Rc308	22.2 I	6.4	4.8 L/I/HI	78.1 F	71.1 Pr	55.2 G1	8.9 G2	3.2 G1	7.1 L	3.2 S	92.1	81.2
IRRIGATED LOWLAND (Special rice)												
NSIC 2013 Rc342SR	20.7 I	6.8	3.6 HI/I	79.3 F	69.5 G1	55.2 G1	10.3 G3	4.9 G1	6.9 L	3.0 I	87.3	65.0
NSIC 2013 Rc344SR	21.9 I	5.7	3.6 I/HI	77.8 F	66.5 G1	48.8 G1	10.2 G2	4.1 G1	7.2 L	3.8 S	85.9	78.1
IRRIGATED LOWLAND (hybrid)												
NSIC 2013 Rc310H	19.7 I	7.9	7.0 L	78.9 F	70.6 Pr	48.2 G2	20.2 aa	6.5 G2	6.4 M	2.8 I	64.8	66.4
NSIC 2013 Rc312H	20.1 I	7.4	7.0 L	76.6 F	68.6 G1	48.1 G1	15.7 aa	7.0 G2	6.6 L	2.8 I	78.3	60.0
NSIC 2013 Rc314H	19.1 I	7.3	5.0 I/L	76.5 F	68.0 G1	49.2 G2	8.9 G2	9.9 G2	6.7 L	2.9 I	83.3	70.8
NSIC 2013 Rc316H	22.4 I	8.6	5.6 L/I	76.7 F	68.9 G1	44.8 G2	15.9 aa	6.4 G2	7.4 L	3.3 S	72.2	61.1
NSIC 2013 Rc318H	21.8 I	-	5.5 L/I	78.1 F	70.9 Pr	52.8 G1	7.7 G2	2.2 G1	7.4 L	3.3 S	73.9	84.3
NSIC 2013 Rc320H	17.4 L	7.9	4.7 I/L	77.6 F	69.5 G1	49.7 G1	9.9 G2	5.7 G2	7.2 L	3.3 S	81.9	76.4
NSIC 2013 Rc322H	19.6 I	7.0	4.8 I/L	77.4 F	68.4 G1	43.9 G2	17.3 aa	4.9 G1	7.0 L	3.1 S	80.0	81.7
RAINFED LOWLAND												
NSIC 2013 Rc346	21.5 I	8.7	3.5 HI/I	77.0 F	68.6 G1	44.3 G2	8.2 G2	2.6 G1	6.8 L	3.2 S	78.3	79.8
NSIC 2013 Rc348	22.1 I	8.2	6.7 L	76.7 F	68.4 G1	44.7 G2	43.6 aa	5.9 G2	7.3 L	3.0 I	83.3	85.3
SALINE												
NSIC 2013 Rc324	20.0 I	-	3.6 I	76.5 F	66.2 G1	44.5 G2	4.9 G1	3.6 G1	7.5 EL	3.2 S	90.0	91.7
NSIC 2013 Rc326	21.3 I	7.9	3.6 I	77.4 F	68.0 G1	40.8 G2	5.7 G2	2.0 Pr	7.0 L	3.2 S	77.8	72.2
NSIC 2013 Rc328	20.7 I	7.5	6.6 L	76.8 F	68.7 G1	43.1 G2	4.2 G1	2.4 G1	7.0 L	3.0 I	88.3	88.3
NSIC 2013 Rc330	6.5 VL	7.5	5.1 I/L	76.5 F	69.0 G1	46.9 G2	24.0 aa	2.8 G1	6.3 M	2.7 I	93.3	86.7
NSIC 2013 Rc332	21.6 L	-	5.2 I/L	78.2 F	69.4 G1	46.4 G2	5.2 G2	2.5 G1	7.0 L	3.2 S	86.7	78.3
NSIC 2013 Rc334	24.0 I	-	5.6 L.HI	76.9 F	67.1 G1	40.8 G2	2.4 G1	6.8 G2	7.7 EL	3.8 S	91.7	91.7
NSIC 2013 Rc336	21.4 I	7.2	3.7 I/HI	76.6 F	66.7 G1	33.2 G3	5.8 G2	2.7 G1	7.4 L	3.7 S	91.7	91.7
NSIC 2013 Rc338	21.6 I	7.8	3.4 HI/I	76.8 F	67.8 G1	39.6 G2	6.8 G2	3.2 G1	6.8 L	3.0 I	90.0	98.3
NSIC 2013 Rc340	25.2 H	9.2	6.7 L	75.9 F	65.6 G1	33.2 G3	5.2 G2	5.1 G2	7.2 L	3.1 S	81.7	100.00

Grain Quality Evaluation:

% chalky & Immature Grain	**Grain Length (mm)**	**Grain Shape (L/W)**	**% Total Milled Rice**
Premium (Pr) 0.1%-2.0%	Extra Long (EL) 7.5 & above	Slender (S) more than 3.0	Premium (Pr) 70.1% & above
Grade 1 (G1) 2.1%-5.0%	Long (L) 6.6-7.4	Intermediate (I) 2.0-3.0	Grade 1 (G1) 65.1%-70.0%
Grade 2 (G2) 5.1%-10.0%	Medium (M) 5.5-6.5	Bold (B) less than 2.0	Grade 2 (G2) 60.1%-65.0%
Grade 3 (G3) 10.1%-15.0%	Short (Sh) 5.4 and below		Grade 3 (G3) 55.1%-60.0%
aa 15.1% and above			
Amylose Content	**% Brown Rice**	**% Head Rice**	**Gelatinization Temp (G.T)**
Waxy/Glutinous (W) <2.0%	Good (G) 80.0% and above	Premium (P) 57.0% & above	Low (L) 6-7 < 70.0 ^{0}C
Very low (VL) 2.1-10.0%	Fair (F) 75.0-79.9%	Grade 1 (G1) 48.0-56.9%	Intermediate (I) 4-5 70.0 ^{0}C - 74.0 ^{0}C
Low (L) 10.1-20.0%	Poor (P) 74.9 and below	Grade 2 (G2) 39.0-47.9%	High Intermediate (HI) 3
Intermediate (I) 20.1-25.0%		Grade 3 (G3) 30.0%-38.9%	High (H) 1-2 74.5 ^{0}C - 80.0 ^{0}C
High (H) 25.1 and above		aa 29.9% and below	

Table 18. Promising lines recommended by RTWG to the Technical Secretariat and eventual approval by NSIC, Special RTWG meeting 27-18 Nov 2013, Manila.

PROMISING ENTRY	REMARKS	DECISION
HYBRID ENTRIES		
PHDR 0913	Passed yield standards for regional and dry season recommendation, good resistance to diseases and insect pests, good grain quality	For Visayas and DS recommendation across regions
PHDR 0911	Passed yield standards for yield, very early maturing, good resistance to insect pest and disease, high amylose content as preferred in Visayas	For Visayas and DS recommendation across regions
PHDR 0912	Passed the yield standards for regional recommendation, good grain quality and intermediate reactions to modified tungro screening	For Visayas recommendation
PR36474H	Passed the yield standards for seasonal recommendation, early maturing , good grain quality and resistance to insect pest and diseases.	For Dry Season Recommendation
PAC 801	Passed yield standards for dry season recommendation but very low wet season performance in Luzon	For Dry Season recommendation (Can be planted for Visayas and Mindanao)
IR81955H	Passed yield standards for regional recommendation, good grain quality, moderate reactions to insect pest and diseases	For Visayas recommendation
BIO 452	Passed yield standards for regional recommendation, acceptable physic-chemical properties and eating quality, resistant to pests	For Visayas recommendation
PHDR 0910	Passed yield standards for regional recommendation, , moderately resistant to modified tungro in IRR, resistant to insects,	For Visayas recommendation
PHDR 0914	Passed yield standards for national recommendation,, good grain quality and resistant to insect pests and diseases.	For National Recommendation
INBRED		
IR80694-44-1-2-2	Did not pass yield standards for national recommendation, but passed regional recommendation for Luzon	For Regional Recommendation (Luzon)
PR37274-6-33-9-1	Passed national yield standard, with good resistance to disease and insect pests, passed grain quality standards	National recommendation
IR78585-98-2-2-1	Did not pass national yield standards, passed number of required trials in Visayas, with good resistance to disease and insect pests, passed grain quality standards	For Regional Recommendation
PR35789-B-1-1-1	Did not pass national yield standards, passed number of required trials in Visayas, with good resistance to disease and insect pests, passed grain quality standards (excellent GQ)	For Regional Recommendation (Visayas)
IR80894-18-2-2-3	Did not pass national yield standards, passed number of required trials in Visayas, with good resistance to disease and insect pests, passed grain quality standards	For Regional Recommendation (Visayas)
IR80894-18-2-2-3	Did not pass national yield standards, passed number of required trials in Visayas, with good resistance to disease and insect pests, passed grain quality standards	For Regional Recommendation
SALINE		
IR83140-B-28-B	Passed yield standards, good insect pest resistance and grain quality	For recommendation in saline-prone areas
IR84675-58-4-1-B-B	Passed yield standards, good grain quality,	

Table 19. Promising lines in the irrigated lowland advanced to the Multi-Adaptation Tests

ECOSYSTEM/GROUP	REMARKS	DECISION
Irrigated lowland (Group 1)		
PR36723-B-13-3-3-3 (tpr/dsr)		
IR08N210 dsr)	Comparable yield	Elevated to MAT
PR37275-5-16-5-2-1-2-1 (AR) (tpr/dsr)		
C8112-B-4-3-2-1-1 (tpr/dsr)		
IR06A150 (tpr/dsr)		
PR36930-B-7-3 (tpr/dsr)		
PR35412-3-9-2-3-1 (tpr/dsr)		
IR06A144 (tpr/dsr)		
PR30996-3B-2-4-5-1-3-2-1 (tpr/dsr)	Good reactions against Blb and Shb	
IR02A127 (tpr/dsr)	Good yield performance under TPR	
HHZ8-SAL6-SAL3-Y2 (tpr)	Low yield in favourable sites	Further test in Saline and Rainfed trials

III. Basic Seed Production of Philippine Rice Varieties and Promising Lines

TF Padolina, HC dela Cruz, TA Alegado, MGT Garcia

Good seeds are both a symbol and foundation of the good life our people have benefited. It is a basic factor of mankind's most sought goal: agricultural abundance. We use it to help end hunger. Seeds are the germ of life, a beginning and an end, the fruit of yesterday's harvest and the promise of tomorrow's. Finding and developing a better seeds is the oldest continuous service rendered to our farmers. Plant breeders and geneticists have worked continuously to aid the selection, advance the harvest and further developed and improved seeds required to produce crops that could better resist drought, cold, salinity, the threat of disease and the attack of insects. The seeds we use today enable our farmers to produce varieties of healthy and good grain quality.

Base population for breeder seed production

- A total of 14, 550 heads were selected from 105 approved varieties and promising lines and 77, 600 panicles were submitted for Breeder Seed Production. (Table 20)

Table 20. Number of head /plants selected and number of panicles submitted, 2013 WS.

Ecosystem	No. of Entries	No. of Head Plants Selected	No. of Panicles for Breeder Seed Production
1. Irrigated Lowland	48	7,200	38,400
2. Rainfed	12	1,800	9,600
3.Cool Elevated	8	1,200	6,400
4. Special Purpose	7	1,050	5,600
5. Submergence	2	300	1,600
6. Saline	18	2,700	14,400
7. Upland	2	300	1,600
Total	97	14,550	77,600

Distinctness, Uniformity and Stability Tests (DUST)

- A total of 191 entries were planted in the seed production plots during the 2013 wet season. Eighty two entries were characterized using IRRI Descriptor for Rice and UPOV DUST guidelines including their distinctness, uniformity and stability performance at all growth stages. Eleven new entries were characterized in Multi location Adaptation Trial (MAT), six are PR lines, 4 IRRI lines, and one from UPLB. Five checks were used in the trials namely PSB Rc82, NSIC Rc224, NSIC Rc222, NSIC Rc240 and PSB Rc18. Among other entries were observed from other ecosystem in the saline, cool elevated, rainfed, upland and special purpose rices.

- Five promising lines were evaluated after two growing seasons and were recommended by the Rice Technical Working Group (RTWG). Among the elite lines were IR80694-44-1-2-2, PR37274-6-33-9-1, IR78585-98-2-2-1, PR35789-B-1-1-1, IR80894 -18-2-2-3. These were the potential varieties for 2014 that will be release as a variety upon approval by the Rice Varietal Improvement Group (RVIG).

- A total of 1460.25 kg pure and viable seeds were distributed for the 2014DS trials. Five hundred forty four kilograms were dispatched to the different NCT trials while nine hundred sixteen kilograms were provided for field performance and screening of Crop Protection Division (CPD) (Table 21).

Table 21. Amount of seed distributed, 2013 WS.

Ecosystem	No. of Entries	No. of Sites	Amount of seed/entry(g)	NCT Trials (kg)	CPD Screening	Total Seeds Distributed
a. MAT (TPR)	16	22	250	88.00	64	152.00
(DWSR)	16	22	450	158.40	64	222.40
b. NCT (TPR)	36	6	250	54.00	144	198.00
(DWSR)	36	6	450	97.20	144	241.20
c. Cool Elevated	19	4	350	26.60	76	102.60
d. Saline	26	3	350	27.30	104	131.30
e. Special Purpose	30	3	350	31.50	120	151.50
f. Rainfed Lowland	25	3	350	26.25	100	126.25
g. Upland	25	4	350	35.00	100	135.00
Total				***544.25***	***916***	***1,460.25***

Purification of Outstanding Selections (POS)

- During the 2013 WS, 179 entries from the various breeding group were planted. These were the best lines generated. The materials were being observed for major morphological agronomic traits such as phenotypic acceptability, crop cut yield, uniformity and maturity. Rouging was done thoroughly throughout the growing period to ensure seed purity. Moderate reaction to bacterial diseases was observed on susceptible entries.

- In terms of yield two entries from drought tolerant ecosystem namely, PR38584-(IR64/AC97WP-128) ID 13-3-7 and PR40858-NSIC Rc9-M4R-370 recorded to have the highest yield of 6.59 t/ha and 6.57 t/ha respectively. Entries from irrigated lowland showed to have promising yield with a yield range from 3.16 to 6.24 t/ha. Significant decrease in yield was noted on all entries due to damaged cause by typhoon Yolanda.

Seed Increase of Varieties and Promising Lines

- A total of 155 varieties and promising lines were multiplied during the 2013 WS. Major agronomic traits were monitored and compared to its original traits. Roguing were done throughout the growing period of the crop to ensure seed purity. Thirty four varieties and promising lines were provided for Participatory Varietal Selections (PVS).

Table 22. Varieties Dispatched to PVS trials

Irrigated Lowland
NSIC Rc298
NSIC Rc300
NSIC Rc302
NSIC Rc222
NSIC Rc308
Irrigated Lowland Promising Lines
PR37274-6-33-9-1 (AR)
PR35789-B-1-1-1
IR80694-44-1-2-2
IR78585-98-2-2-1
IR80894-18-2-2-3
Irrigated Lowland Special Purpose
NSIC Rc342SR
NSIC Rc344SR
NSIC Rc304 (J)
NSIC Rc242 SR
NSIC Rc21 SR
NSIC Rc218SR
Rainfed Lowland Dry Seeded
NSIC Rc346
NSIC Rc348
NSIC Rc274
NSIC Rc286
NSIC Rc288
NSIC Rc192
Cool Elevated
NSIC Rc104
PR29399-B-2-2-1
PR28705-B-3-86
PR34131-B-11-1
PR29814-B-5
PR30225-B-13-1
Saline
NSIC Rc326
NSIC Rc330
NSIC Rc290
NSIC Rc292
NSIC Rc296
NSIC Rc184
Submergence Tolerant
PSB Rc68

IR80694-44-1-2-2

PR37274-6-33-9-1

IR78585-98-2-2-1

PR35789-B-1-1-1

IR80894 -18-2-2-3

Figure 11. Promising lines from MAT, 2013 WS

IV. Development of Hybrid Rice Varieties

DA Tabanao

The success of hybrid rice technology lies mainly in the development of high yielding varieties adapted to local conditions. Between 1994 and 2011, the National Seed Industry Council has approved a total of 44 hybrid varieties for commercial cultivation in the Philippines. Seventeen of these varieties were bred and developed by the public sector, of which six were bred by PhilRice together with its partners UPLB and PhilSCAT. To date, PhilRice breeders at its Central Experiment Station, and branch stations in Los Baños (in collaboration with UPLB) and in San Mateo, have maintained specialized breeding activities despite the steady rise of private sector participation in this particular enterprise. The continuous development of high-yielding hybrid varieties that are resistant to pests and diseases and possess excellent grain qualities is essential to keep up with the increasing demand for rice and the changing environment. As such, there is a need for a strong national public breeding and research on hybrid rice.

Development of hybrid parent lines

LV Gramaje, VP Luciano, MSF Ablaza, KA Garcia, JE Carampatana, MM Rosario, JM Domingo and DA Tabanao

One of the challenges in hybrid breeding is the selection, development and improvement of suitable parental lines that can be used for developing hybrids. In hybrid rice breeding, the cytoplasmic male sterile (CMS) line is considered as the heart in the development of F1 hybrids because failure in purity of this will result to poor hybrid. Therefore, CMS line development is a very essential component in the development of hybrid rice. Because of its great role and importance, diverse CMS lines with good qualitative and quantitative traits must be developed. Introduced CMS lines often are not adapted to local conditions, with very low resistance to biotic stresses and poor grain quality.

Maintainer and restorer lines are very essential components in the development of hybrid rice as well. Without maintainer and restorer lines, multiplication of CMS lines and production of F1 are not possible. Continuous research on the identification of inbred cultivars that can either maintain the sterility or restore the fertility of CMS lines plays an important role in developing high-yielding germplasm pools. Therefore, there is a need to develop new maintainer and restorer lines and improve existing ones.
The study aimed to: (1) develop new diverse and stable CMS lines with good morphological traits and flowering behavior; (2) to develop and improve maintainer lines with good maintaining ability and desired plant morphology and grain quality; (3) to develop and improve restorer lines with desirable morphological traits, moderate resistance to pest and diseases and accept-

able grain quality and (4) to develop new Thermo-sensitive Genetic Male Sterile (TGMS) line with good agronomic traits, flowering behavior, moderate resistance to pest and diseases, adaptable to local condition and good grain quality.

Highlights:

- For maintainer line development, a total of 118 selected maintainer lines with desirable morphological traits were assembled. Through hybridization, 16 new BxB crosses were generated (Table 23). Furthermore, 6 out of 14 F1 crosses were evaluated and bulked to be advanced to F2 generation. A total of 1,223 entries will be advanced for further evaluation. Of these, 113 are plant selections from 5 F2 populations, 99 plants from 190 F3 entries, 292 plants from 65 F4 entries, 332 plants from 632 F5 entries, and 372 plants from 86 F6 entries (Table 24). Two uniform maintainer lines from the F7 population will be used as new parent and crossed to CMS lines to evaluate their maintaining ability. Detailed cross combination of lines that will be advanced in 2014 DS is shown in Table 25.

- For CMS conversion, 38 inbred lines with the desired traits were assembled. These potential maintainer lines were obtained from plant selections from elite breeding materials of the maintainer development nursery. Six lines were used for re-testcrossing to CMS lines and included in the backcross nursery to further evaluate their maintaining ability. Boots were collected for pollen sterility evaluation under the microscope before backcrossing. Pollen sterility of the F1 was evaluated in the following season. Forty-four plants from 21 BC1F1 entries, 14 plants from 28 BC2F1 entries, 16 plants from 38 BC4F1 entries, 31 plants from 31 BC5F1 entries, and 6 plants from 3 BC6F1 entries were found to have 100% sterility and were advanced to the next generation. Progeny lines are to be repeatedly backcrossed up to the fifth generation. Detailed cross combination of lines that will be advanced in 2014 DS is shown in Table 26. New CMS lines with stable sterility and good agronomic characters will then be declared and used as new testers in the Source Nursery. CMS lines with PR35746-HY-6-6-2-1-1-1 background will be seed produced and will be characterized in 2014.

- For TGMS line development, 78 male pollen parents were crossed to three S-lines (PR41917S, PR41918S and PR41919S) in the TGMS source nursery (TSN). The testcrossing generated 240 F1 plants to be evaluated on 2014 DS along with their parent lines. On the other hand, 626 F2 and 317 F3 sterile plants in the pedigree nursery with good morpho-agronomic characters were evaluated and selected at Male Sterile Environment (MSE) at PhilRice CES on 2013 WS. These sterile plants were ratooned and planted at Male Fertile Environment (MFE) in Kayapa, Nueva Vizcaya for evaluation and seed multiplication (Figure 12). From 211 F1 plants during 2013 WS, 5 entries were selected and will be advanced to SPON and 18 selected F2 entries will be established on 2014 DS. The selected sterile plants from 18 F2 will be ratooned and will be transferred to male fertile environment (MFE) in Kayapa, Nueva Vizcaya.

- For restorer line development, 560 out of 1145 entries were selected (Figure 13). These entries consist of 85 F1 crosses, 92 F2 plants, 150 F3 plants, 580 F4-F5 plants, and 245 F6-F7 plants which will be evaluated on 2014 DS (Table 27). Selection was based on phenotypic acceptability and morpho-agronomic traits. Forty advanced elite lines selected from the F8 generation were established in the male parent yield trial (MPYT) nursery for yield and yield components evaluation. Table 28 showed the top 20 high yielding restorer advanced elite lines including the checks PSB Rc18, PSB Rc82 and NSIC Rc240. The yield performance was affected due to typhoon Santi which caused lodging of these entries. Notably, PR36641-HY-8-1-3-1 yielded 3522 kg/ha, higher than the check PSB Rc18 with 2830 kg/ha. This entry will be advanced to the SPON while the rest of the entries will be evaluated for yield and other morpho-agronomic characteristics in 2014 DS.

Table 23. Crosses generated in the maintainer line development nursery.

Designation	Parents		Plants selected
PR46649-HY	PR42597-HY-AC-6	IR80559B	1
PR46648-HY	PR42597-HY-AC-2	PR24B	1
PR46647-HY	PR42597-HY-AC-8	IR58025B	1
PR46646-HY	BB-11	PRH1B	1
PR46645-HY	PRH1B	BB-11	1
PR46644-HY	PR2B	PRH1B	1
PR46643-HY	PR9B	PR21B	1
PR46642-HY	PR21B	PRH1B	1
PR46641-HY	PR21B	PR9B	1
PR46640-HY	IR79128B	PR42597-HY-AC-7	1
PR46639-HY	IR79128B	IR68897B	1
PR46638-HY	IR79128B	PR24B	1
PR46637-HY	IR80559B	PR42597-HY-AC-6	1
PR46636-HY	IR80559B	PR42597-HY-AC-7	1
PR46635-HY	IR80156B	PR42597-HY-AC-3	1
PR46634-HY	IR58025B	IR80151B	1
TOTAL			16

Table 24. Entries evaluated and selected in the maintainer line development nursery.

Generation	Entries evaluated	Plants selected
F_1	14	6
F_2	5	113
F_3	190	99
F_4	653	292
F_5	632	332
F_6	816	372
F_7	20	9*
TOTAL	2330	1223

**Uniform elite lines selected for CMS conversion in 2014 DS*

Table 25. Summary of entries in the maintainer line development nursery.

Gen	Designation	Parents		Entries Evaluated	Plants selected
F_1	PR46191-HY	PR2B	PR3B	1	1
	PR46189-HY	PR9B	PR2B	1	1
	PR46188-HY	PR9B	IR68897B	1	1
	PR46187-HY	PR19B	PR3B	1	1
	PR46185-HY	PR21B	PR2B	1	1
	PR46184-HY	PR21B	IR72079B	1	1
F_2	PR46182-HY	IR79128B	PR42597-HY-AC-2	1	24
	PR46181-HY	IR79128B	PR40591B	1	45
	PR46180-HY	PR42597-HY-AC-2	IR68897B	1	30
	PR46179-HY	PR40591B	PR42597-HY-AC-1	1	6
	PR46178-HY	IR68897B	PRH1B	1	8
F_3	PR46177-HY	L-107-2	PR21B	11	2
	PR46176-HY	L-106-2	PR35746-6-6-2-1-1	7	2
	PR46175-HY	L-107-3	PR21B	5	11
	PR46174-HY	L-106-2	PR24B	10	9
	PR46172-HY	PRH1B	JX 316B	3	2
	PR46171-HY	L-106-2	IR68897B	4	8
	PR46170-HY	IR58025B	PR21B	11	6
	PR46169-HY	IR68897B	L-106-1	12	3
	PR46168-HY	PRH1B	BB-8	12	7
	PR46167-HY	IR79128B	PR9B	11	4
	PR46166-HY	L-107-3	IR58025B	10	2
	PR46165-HY	IR79128B	IR58025B	10	6
	PR46164-HY	BB-8	PR21B	9	10
	PR46162-HY	PR1B	L-108-8	10	5
	PR46161-HY	IR80151B	BCN 127B	7	1
	PR46160-HY	L-106-1	PR9B	10	5
	PR45964-HY	IR58025B	PR9B	45	16
F_4	PR46624-HY	IR68888B*6/ IRBB62		1	3
	PR46629-HY	IR71604R	IRBB54	1	3
	PR46623-HY	IR68897B*5/ IRBB62		1	1
	PR46627-HY	PR39929-97B50-B	IR68897B	5	12
	PR46632-HY	IR68897B-25	Matatag 6	3	6
	PR46630-HY	PR39904-25B-65-8-1-15	IR58025B	1	3
	PR45965-HY	JX316B	PR9B	69	24
	PR41883-HY	PR4B	IR58025B	18	1
	PR45966-HY	PR4B	B38	4	1
	PR45967-HY	IR58025B	IR73328B	45	10
	PR45968-HY	PR4B	PR9B	113	33
	PR45969-HY	IR70369B	JX316B	13	6
	PR45970-HY	IR70369B	PR4B	12	2
	PR45962-HY	PR45962-HY		68	24
	PR45963-HY	PR45963-HY		81	76

Table 26. Summary of entries in the CMS conversion nursery.

Gen	Designation	Parents		Entries Evaluated	Crosses Generated	Plants Selected
New	PR46622-HY	IR68897A	PR46098-HY-2-7-7-1-1		1	1
	PR46621-HY	PR21A	PR46098-HY-2-7-7-1-1		3	3
	PR46620-HY	IR68897A	PR40561-HY-1-1-1-1		2	2
	PR46619-HY	PR21A	PR40561-HY-1-1-1-1		4	4
	PR46618-HY	IR68897A	IR94641-3-1-PR-1-1		1	1
	PR46617-HY	PR21A	IR94641-3-1-PR-1-1		3	3
	PR46616-HY	IR68897A	IR95761-16-PR-1-1		2	2
	PR46615-HY	PR21A	IR95761-16-PR-1-1		1	1
	PR46614-HY	IR68897A	IR95766-23-PR-1-1		5	2
	PR46613-HY	PR21A	IR95766-23-PR-1-1		6	6
	PR46612-HY	IR68897A	IR95766-1-PR-1-1		7	4
	PR46611-HY	PR21A	IR95766-1-PR-1-1		4	4
BC1F1	PR46159-HY	IR68897A	PR40562-HY-1-9	2	7	7
	PR46158-HY	IR68897A	PR40565-HY-2-1-10	2	11	9
	PR46157-HY	IR68897A	PR40569-HY-4-9	2	28	23
	PR46155-HY	IR68897A	PR41283-HY-4	1	2	3
	PR46150-HY	IR68897A	IR95766-24-PR-1	2	2	2
BC2F1	PR46147-HY	IR68897A	IR90962-2-1 (T 3457)	2	4	4
	PR46144-HY	PR2A	Nipponbare-orig-AC-2-1-10-1-1	2	2	2
	PR46143-HY	PR2A	Nipponbare (GEMS)-29-7	2	3	3
	PR46141-HY	PR2A	PR36831-55-2-1-1-1-1-1	4	2	3
	PR46140-HY	IR68897A	PR34131-B-20-1	2	2	2
BC4F1	PR46132-HY	IR79128A	PR40569-HY-1-3	16	54	9
	PR46131-HY	IR79128A	PR40569-HY-1-11	13	48	7
BC5F1	PR46129-HY	IR68897A	PR35746-HY-6-6-2-1-1-1	22	136	19
	PR46128-HY	PR21A	PR35746-2-2-2-1-4-2	8	35	10
	PR35665-HY	IR73328A	C7176-B-2-3	1	2	2
BC6F1	PR46127-HY	PR15A	PR37130-HY-3-3-1-2-1-19(B38)	3	11	6
TOTAL				84	388	144

Table 27. Evaluation of restorer lines based on phenotypic acceptability

Generation	No. of entries evaluated	No. of entries selected	No. of plants to be advanced
F_1	118	105	85
F_2	4	3	92
F_3	237	203	150
F_4-F_5	300	89	580
F_6-F_7	163	42	245
F8	268	33	-
RYT	55	55	40
Total	1145	530	1192

Table 28. Yield of restorer lines (adversely affected by typhoon Santi) in the male parent yield trial during 2013 WS.

No.	Entries	Yield (kg/ha)
1	PR36641-HY-8-1-3-1	3522
2	PR42441-HY-15-1-1-1-1	2898
3	PR36620C-HY-20-1-2-2-1	2681
4	PR36620C-HY-19-10-2-2-1	2660
5	PR36620C-HY-19-6-9-1-1	2578
6	PR36637-HY-2-1-2-1	2549
7	PR36642-HY-6-5-4-3-1	2544
8	PR36642-HY-7-3-5-1-1	2504
9	PR42444-HY-1-1-2-1	2447
10	PR36642-HY-6-5-5-3-1	2432
11	PR36642-HY-7-5-4-1-1	2413
12	PR36641-HY-9-1-1-2-1	2372
13	PR42438-HY-13-1-1-3-1	2359
14	PR36642-HY-6-1-9-3-1	2312
15	PR42444-HY-3-1-3-1	2198
16	PR42439-HY-15-1-1-1-1	2159
17	PR36642-HY-6-1-8-2-1	2144
18	PR42448-HY-8-1-1-1	2136
19	PR43312-HY-2-2-3-1	2131
20	PR36620C-HY-19-1-5-1-1	2121
21	NSIC Rc240 (check)	3741
22	PSB Rc82 (check)	3572
23	PSB Rc18 (check)	2830

Figure 12. Establishment of F2 and F3 selected TGMS plants from the pedigree nursery in the Male Fertile Environment (MFE) in Kayapa, Nueva Vizcaya for seed multiplication. These plants were ratooned from Male Sterile Environment (MSE) at PhilRice CES during 2013 WS.

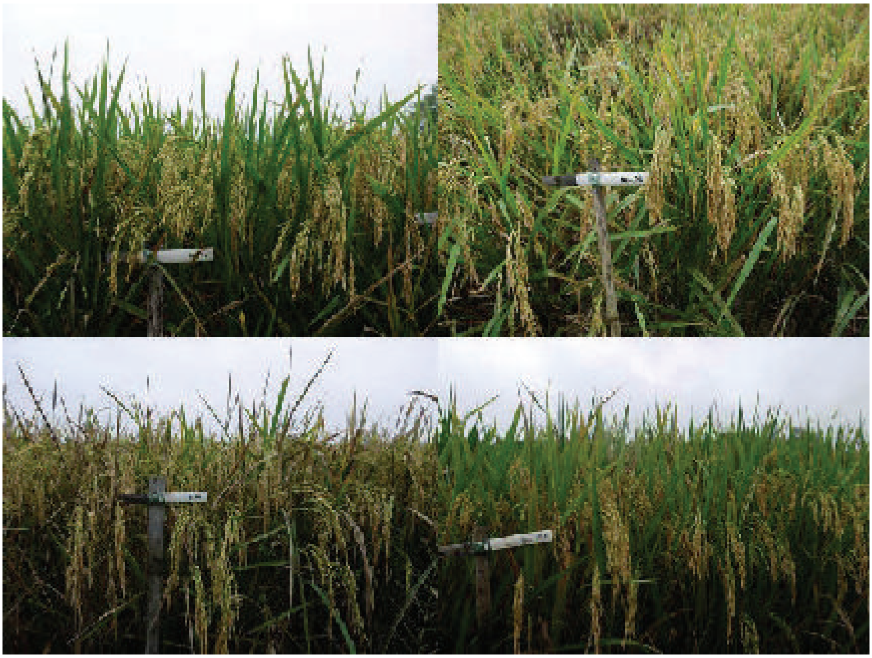


Figure 13. Breeding lines with good phenotypic acceptability in the restorer line pedigree nursery, 2013 WS.

Development of F1 hybrids
VP Luciano, MM Rosario, MSF Ablaza, JM Domingo, DA Tabanao

The three-line system in hybrid breeding is a key approach to help attain rice self-sufficiency in the country. 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. Heterotic hybrids also offer high income opportunities to the farmers. This is either through F1 cultivation or parental seed production. The success of hybrid rice breeding depends to a great extent on the quality and diversity of elite lines used as parents in developing new hybrids. New approaches such as the use of excellent inbreds and promising lines from Optimum Plant Morphology (OPM), Tropical Japonica (TJ) breeding, and doubled haploid (DH), are essential in discovering promising new hybrid combinations.

The main goal of the study was to identify superior F1 combinations as well as to determine the combining ability of newly developed parent lines. Specifically, the study aimed to (1) identify potential maintainer lines (B) or restorer lines (R) from the early generation and elite breeding lines of irrigated lowland inbred rice breeding project, (2) to developF1 hybrids from a cross between cytoplasmic male sterile (CMS) lines, DH, OPM and TJ lines from the inbred rice breeding project, (3) to convert potential B lines into new A lines and utilize potential R lines in further enhancing the restorer line genepool of hybrid breeding program of PhilRice.

Highlights:

- Established in the source nursery I (SN I) was 88 (2013 WS) parent lines composed of irrigated lowland (IL), double haploids (DH), tropical japonica (TJ) and optimized plant morphology (OPM). These entries were crossed to three CMS lines (PR2A, IR68897A, IR58025A) generating 856 F1 (DS) and 193 F1 seeds (WS) (Table 29). The generated F1 hybrid entries including their parent lines will be evaluated in the testcross nursery (TCN I) on 2014 DS (Figure 14).

- For TCN I, 1238 parent lines and 1529 F1 hybrids were evaluated on 2013 WS and DS. There were 40 (DS) and 27 (WS) parent lines identified as potential restorer while 90 (DS) and 36 (WS) lines were identified as potential maintainers (Table 29). The potential restorer lines will undergo re-testcrossing to evaluate combining ability, while the potential maintainers will be elevated to the backcross nursery. Among the F1 hybrids, eight entries (AC-TCN-6, AC-TCN-3, AC-TCN-49, AC-TCN-44, TJ-TCN-80, TJ-TCN-79, IL-TCN 50 and TJ-TCN-74) showed 4.7-243.3% yield advantage over the check varieties. AC-TCN-6 was noted to have the highest actual yield of 664.8 g and with the highest yield advantage of 243.3% over the check variety NSIC Rc222 (Table 30). The top five high yielding parent lines in TCN I were AC TCN-48, AC TCN-18, AC TCN-36, AC TCN-60, and AC TCN-56 with corresponding yield of 546.7 g, 488.4 g, 479.1 g, 457.1 g, and 454.9 g (Table 31).

- The parent lines of the selected F1 hybrids from TCN I were advanced to the source nursery II (SN II) for testcrossing to eight CMS lines (IR68897A, IR58025A, PR2A, PR9A, PR15A, PR21A, TGMS71, and PR19A). The SN II in 2013 generated 790 F1 (DS) and 842 F1 (WS) hybrids (Table 29). The generated hybrids will be evaluated along with their parent lines in the testcross nursery II (TCN II) in the succeeding season.

- For TCN II in 2013 WS, 165 parent lines and 677 F1 hybrids were evaluated (Table 29). Three parent lines had 26-184.6% yield advantage over the four checks PSB Rc18, PSB Rc82, NSIC Rc222, and NSIC Rc240. The F1 hybrids coded as ReTCN-501, ReTCN-127 and ReTCN-850 were noted to have the highest yield advantage of 147.1%, 141.0%, and 137.8% over the check NSIC Rc222 (Table 30). The selected F1 from TCN II will be advanced to seed production observational nursery (SPON) for further evaluation and seed increase. In TCN II, 42 were identified as potential restorer or as pollen parents and 21 lines identified as potential B lines during 2013 DS (Table 29 and Figure 14). The potential restorer lines will undergo re-testcrossing to evaluate their combining ability while the potential maintainers will be elevated to the backcross nursery.

Table 29. Breeding lines and hybrids in the source nursery (SN) I and II, testcross nursery (TCN) I and II at PhilRice CES.

Nursery	Entries	Number of entries							
		2013 DS				2013 WS			
		IL	OPM/TJ	DH	Total	IL	OPM/TJ	DH	Total
SN I	No. of parents	150	161	32	343	38	31	19	88
	No. of F1	398	419	39	856	99	87	7	193
SN II	No. of parents	382	30	0	412	201	20	71	292
	No. of F1	790		0	790	453	96	294	843
TCN I	No. of parents	123	130	72	325	423	419	71	913
	No. of F1	275	473	72	820	356	308	45	709
	Potential R or P	0	40	0	40	6	21	0	27
	Potential B-line	30	60	0	90	26	10	0	36
TCN II	No. of parents	71	141	0	212	65	100	0	165
	No. of F1	268	666	0	934	358	319	0	677
	Potential R or P	0	0	0	0	42	0	0	42
	Potential B-line	0	0	0	0	21	0	0	21

SN I and TCN I - 3 CMS lines; SN II and TCN II - 8 CMS lines.

Table 30. Yield and yield advantage of F1 hybrids in the testcross nursery I and II.

Entries	Yield (g)	Yield advantage (%)			
		PSB Rc18	PSB Rc82	NSIC Rc222	NSIC Rc240
Testcross nursery I					
AC-TCN-6	664.7	88.9	112.8	243.3	86.6
AC-TCN-3	600.7	70.7	92.3	210.3	68.6
AC-TCN-49	553.3	57.2	77.1	185.8	55.3
AC-TCN-44	419.4	19.2	34.3	116.6	17.7
TJ-TCN-80	405.3	15.2	29.7	109.3	13.8
TJ-TCN-79	383.3	8.9	22.7	98.0	7.6
IL-TCN 50	378.8	7.6	21.3	95.7	6.3
TJ-TCN-74	372.9	6.0	19.4	92.6	4.7
Testcross nursery II					
ReTCN-501	478.3	35.9	53.1	147.1	34.3
ReTCN-127	466.6	32.6	49.4	141.0	31.0
ReTCN-850	460.3	30.8	47.3	137.8	29.2
ReTCN-376	459.0	30.4	46.9	137.1	28.9
ReTCN-88	448.9	27.6	43.7	131.9	26.0
ReTCN-463	392.5	11.5	25.6	102.7	10.2
ReTCN-166	389.1	10.6	24.6	101.0	9.2
ReTCN-506	376.0	6.8	20.4	94.2	5.6
ReTCN-90	367.9	4.5	17.8	90.0	3.3
ReTCN-130	366.7	4.2	17.4	89.4	2.9

Table 31. Yield of parent lines and check varieties in the testcross nursery I and II.

No.	Parent lines	Yield (g)
Testcross nursery I		
1	AC TCN-48	546.7
2	AC TCN-18	488.4
3	AC TCN-36	479.1
4	AC TCN-60	457.1
5	AC TCN-56	454.9
6	AC TCN-20	446.8
7	AC TCN-7	446.1
8	AC TCN-68	435.8
9	TJ-TCN 310	435.7
10	AC TCN-51	420.3
Testcross nursery II		
1	ReTCN-495	550.9
2	ReTCN-135	501.2
3	IL-TCN-88	448.9
Check varieties		
4	PSB Rc18	351.9
5	PSB RCc82	312.4
6	NSIC Rc222	193.6
7	NSIC Rc240	356.2

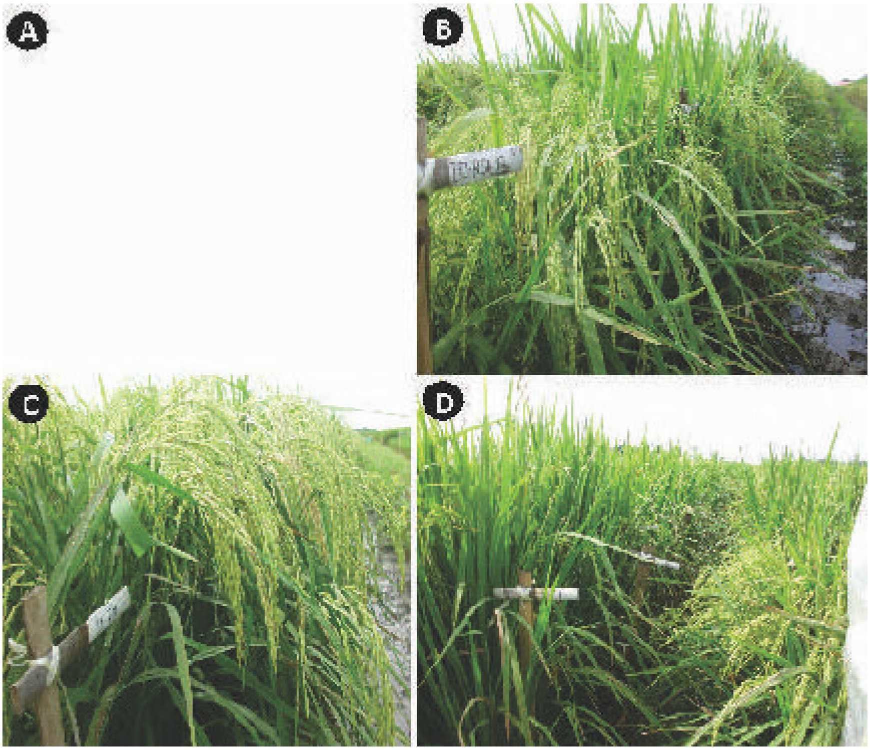


Figure 14. Breeding lines evaluated in the source nursery I (A), source nursery II (B), testcross nursery I (C) and testcross nursery II (D).

Performance test of experimental hybrids

MSF Ablaza, LV Gramaje, JE Carampatana and DA Tabanao

Heterosis breeding is one complementary strategy to negate the growing rice shortage in the country, as it promises a 15% yield advantage compared to conventional varieties under the same input levels. The increases in yield are a result of hybrid vigor that breeders aim to exploit.

Good hybrids identified in the different yield trials provide the mechanisms for scientifically investigating the performance of promising hybrids for yield, level of their heterosis and resistance to pests and diseases over designated check cultivars under local conditions. This information is important in selecting the best hybrids for multi-location national trials for hybrids under the National Cooperative Test.

The objectives of the study were: (1) to evaluate the performance of promising hybrid combinations in different nurseries for yield, reaction to biotic stresses and other desirable traits; (2) to identify hybrids with broad range of adaption and stable performance across location; and, (3) to identify location/season specific hybrids.

Highlights:

- In 2013 WS, 102 entries comprised the observation nursery (ON) with five check varieties. The experiment was laid out in augmented design where check varieties were replicated in each block while the test entries were not replicated but assigned to the plots randomly. The F1 hybrids were evaluated along with their respective male parents for comparison in terms of morpho-agronomic traits (Figure 15). The checks were PSB Rc18, PSB Rc82, NSIC Rc222, Mestiso 19 and Mestiso 29. Grain yield data were evaluated selecting top ten entries based on high yielding ability and good phenotypic acceptability against the check varieties. The top three entries were PR46358H, PR46382H and PR46483H (Table 32).

- The Preliminary Yield Trial (PYT) consisted of promising hybrids selected from the ON (Figure 16). Against five check varieties, 61 entries were evaluated in the WS, laid out in randomized complete block design (RCBD), replicated 3 times with 10 rows and 25 hills per plot. A set of hybrids were selected as top seven entries, five of which having restorer lines developed through anther culture (PR45594HY-AC, PR44107H, PR45613HY-AC, PR45605HY-AC, PR36575H, PR45581HY-AC and PR45587HY-AC), and almost all of which had yield advantage of at least 15% against PSB Rc18 and Mestiso19 (Table 33). All identified best hybrid entries in the trial will be advanced to Seed Production for National Cooperative Test (SPNCT) prior to National Cooperative Test evaluation.

- Multi-location yield trials (MYT) serve to evaluate the extent of adaptation of experimental and released hybrids in varied environmental conditions, primarily determined by grain yield. The MYT in 2013 WS consisted of 20 entries including PSB Rc18, PSB Rc82 and NSIC Rc240 as check varieties. The tests were conducted at PhilRice CES and PhilRice Isabela (Figure 17). Mestiso 25, Mestiso 26, Mestiso 29, CPR 004 and Mestiso 21 were the top five entries at PhilRice CES with GY ranging from 2.98 t ha-1 (M21) to 3.61 t ha-1 (M25), while PR36559H, Mestiso 21, Mestiso 26, PR40641H and CPR 003 were the top five entries at PhilRice Isabela with GY ranging from 7.79 t ha-1 (PR36559H) to 9.54 t ha-1 (CPR 003) (Table 34). Only Mestiso 25 posted a YA of >15% against all three checks at PhilRice CES, while only PR36559H posted a YA of >15% over NSIC Rc240 at PhilRice Isabela.

Table 32. Grain yield of observation nursery entries during 2013 DS and WS.

2013 WS	
Entry	**Grain Yield (t ha^{-1})**
PR46358H	5.30
PR46382H	5.14
PR46483H	4.55
PR46481H	4.35
PR46380H	4.37
PR46388H	4.26
PR46393H	4.17
PR46395H	3.93
PR46368H	3.90
PR46363H	3.82
PSB Rc82	6.14
PSB Rc18	4.13
Mestiso 19	4.20
Mestiso 29	7.98
NSIC Rc222	4.55

Table 33. Grain yield and yield advantage against check varieties of 2013 WS preliminary yield trial entries.

Pedigree	Grain Yield (t ha^{-1})	Yield advantage			
		PSB Rc18	PSB Rc82	Mestiso 29	Mestiso 19
PR45594HY-AC	3.14	80.86	29.23	10.22	35.98
PR44107H	3.04	74.89	24.97	6.58	31.49
PR45613HY-AC	2.74	57.76	12.73	-3.86	18.61
PR45605HY-AC	2.65	52.81	9.19	-6.88	14.89
PR36575H	2.64	51.73	8.42	-7.53	14.08
PR45581HY-AC	2.54	46.47	4.66	-10.73	10.13
PR45587HY-AC	2.53	45.55	4.01	-11.30	9.43

Table 34. Grain yield and yield advantage against the check varieties of 2013 WS multi-location yield trial entries at PhilRice CES and PhilRice Isabela.

PhilRice Isabela				PhilRice CES				
Entry	Grain Yield (t ha^{-1})	Yield advantage PSB Rc82	Yield advantage PSB Rc18	Entry	Grain Yield (t ha^{-1})	Yield advantage PSB Rc82	Yield advantage PSB Rc18	Yield advantage NSIC Rc240
PR36559H	9.54	21.17	14.50	Mestiso 25	3.61	20.75	34.98	37.98
Mestiso 21	8.67	10.05	4.00	Mestiso 26	3.41	14.06	27.49	30.33
Mestiso 26	7.79	-1.06	-6.50	Mestiso 29	3.11	3.97	16.22	18.80
PR40641H	7.79	-1.06	-6.50	CPR 004	2.99	0.17	11.97	14.46
CPR 003	7.79	-1.06	-6.50	Mestiso 21	2.98	-0.44	11.29	13.77
PSB Rc82	7.88			PSB Rc82	2.99			
PSB Rc18	8.33			PSB Rc18	2.67			
				NSIC Rc240	2.62			

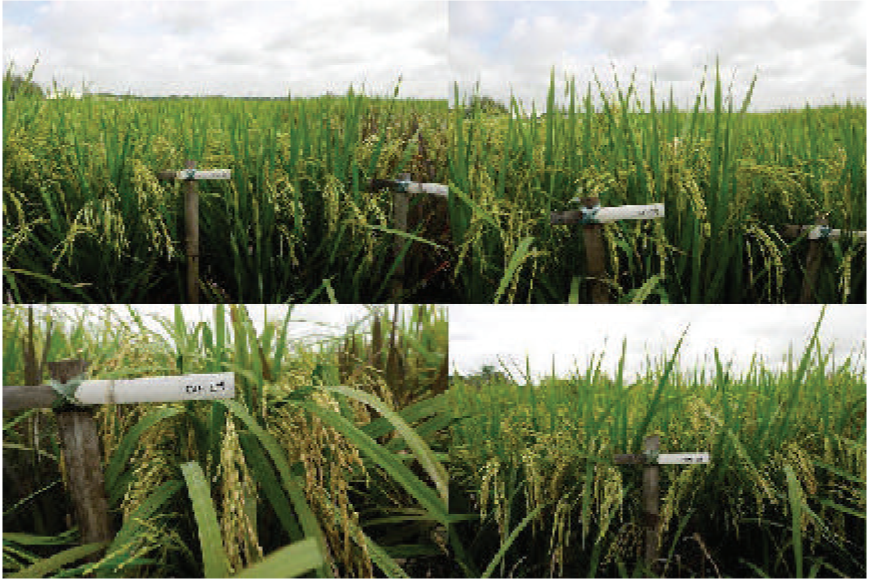


Figure 15. Breeding lines evaluated in the observation nursery 2013.

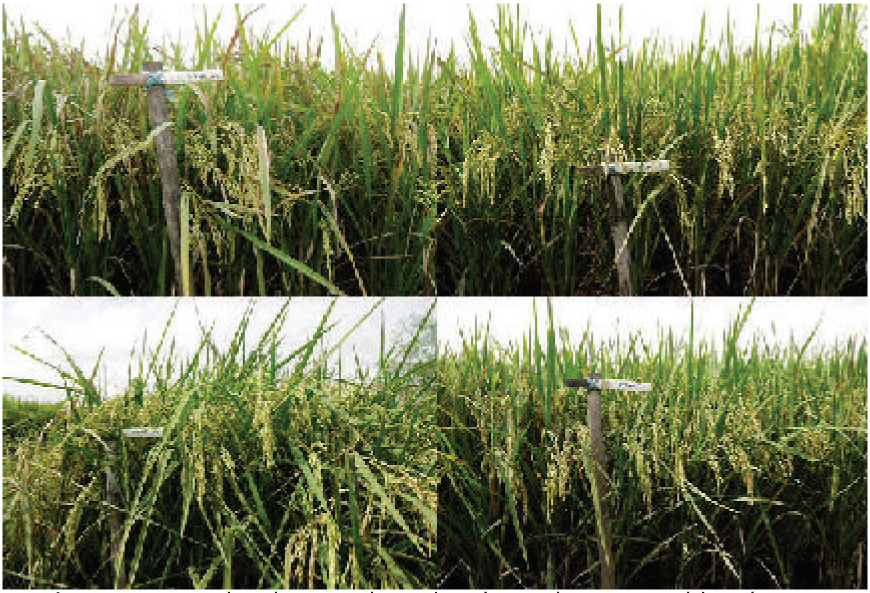


Figure 16. Breeding lines evaluated in the preliminary yield trial 2013.

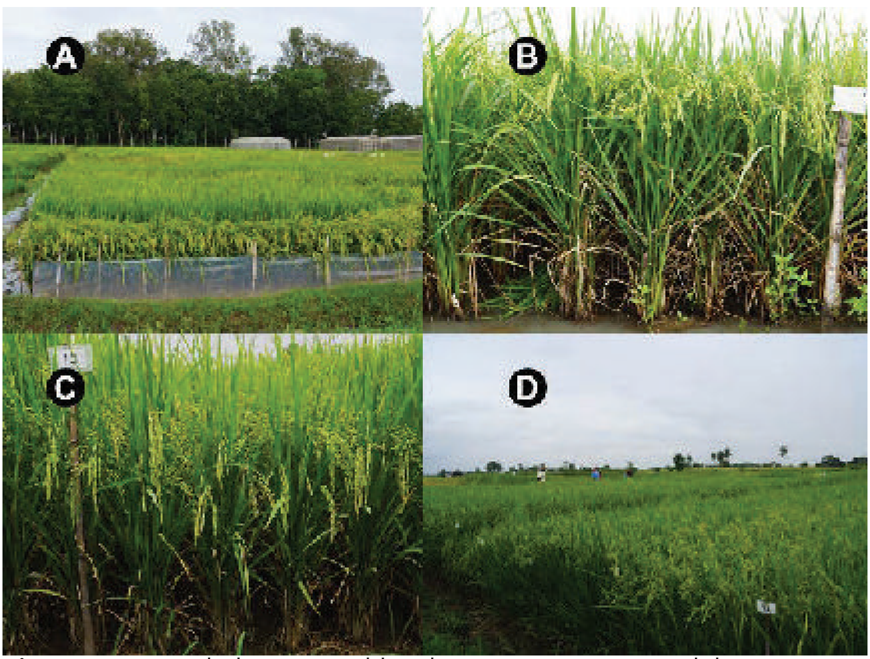


Figure 17. (A) Multi-location yield trial (MYT) 2013 setup at PhilRice CES, (B) an MYT entry at PhilRice CES, (C) an MYT entry at PhilRice Isabela, (D) MYT setup at PhilRice Isabela.

Yield prediction of single cross hybrids and combining ability analysis of parent lines

JM Domingo, LGramaje ,JE Carampatana, AEPocsedio and DA Tabanao

At present, the implementation of hybrid rice technology is being hampered by the high cost of field evaluation. This is due to the strategy of breeding programs that includes performing all possible crosses in a group of inbred lines and then evaluating the single cross hybrids obtained, followed by the selection of the most promising ones. It is also quite difficult and expensive to assess a very large number of developed parent lines and evaluation of all possible hybrids. Consequently, it is imperative to find alternative procedures to evaluate large number of hybrid lines. One alternative is the use of genetic parameter estimation which allows the prediction of non-observed hybrid performance. Traditionally, field trials or progeny tests are used to choose the best parents which include generating hundreds of crosses under field evaluation. Plant breeders spend a huge amount of time, labor, and effort in the development of most suitable genotypes with multiple variations during selection. However, the time, labor and energy cost could be reduced using an efficient prediction method. A reliable method of predicting hybrid performance is needed.

Among the hybrid performance prediction methods, best linear unbiased prediction (BLUP), this combines field testing of related hybrids and obtaining pedigree information or genetic relatedness, holds great promise (Charcosset et al., 1998). According to Henderson (1986), BLUP is the most appropriate method to predict genetic parameters in hybrids as supported by Bernardo (1994, 1995, 1996a, 1996b). Yield prediction of hybrid performance is a result of good combining ability. The combining ability of the different lines has a major importance in hybrid breeding since it provides information for parent selection and the nature and magnitude of gene action involved. The knowledge of genetic structure and mode of inheritance of different characters helps breeders to employ the suitable breeding methodology for their improvement (Kiani et al., 2007)
In the last several years, Bernardo has attempted to use BLUP in maize breeding with interpopulation genetic models that involve both GCA and SCA. Outcome of these studies have indicated that BLUP is useful for routine prediction of single-cross performance in plant breeding particularly in maize. The predicted performance of single crosses could be used to predict the performance of F2 x tester combinations, three-way crosses, or double crosses. Along with the pedigree relationship, the BLUP method can use trait data, or both trait and marker data, for prediction (Bernardo 1994, 1996).
This study aimed to: (1) determine the yield performance of tested and untested single cross hybrids through best linear unbiased prediction; (2) measure the general and specific combining ability of hybrid parent lines for yield traits; (3) identify the best performing hybrids and parents through BLUP and combining ability.

Highlights:

2013 WS

Assembly of parent lines

- A total of 96 hybrid parentals were assembled. This includes 29 CMS with their maintainer lines and 67 restorer lines. CMS lines were used in crossing and their respective maintainers will be planted together with the F1s to serve as parental checks in the nurseries. The entries were assembled from the breeding pool of hybrid breeding program of the institute. The entries are parentals of released as well as promising hybrids.

F1 development for Best linear unbiased prediction (BLUP) and Combining ability analysis

- The parents were planted in staggered to maximize the availability of parents in generating paired crosses. The A lines were sown in three batches and transplanted in the field in 1.2 m × 8 m plots to ensure the synchronization with the pollen parents while the R lines were in two batches in 0.6 m × 6 m plots. In generating the F1 seeds, approach method of A × R paired crossing was done in hybridization cages (Figure 18).

- A total of ten CMS, namely PR2A, PR15A, PR20A, IR68897A, IR58025A, IR79128A, IR80559A, IR80156A, IR73328A and IR80151A and 39 R lines were used to form 164 F1s with 683 seeds (Table 35).

- Crosses with enough seed will be planted in combining ability and BLUP nurseries. For combining ability, 32 cross combinations were used (Table 36). These crosses were divided into three sets with 16 crosses each (some crosses appear in more than one set) derived from a mating design of 4 lines by 4 testers. The 16 entries including 8 parents and the check variety, Mestiso 29 will be laid out in randomized complete block design (RCBD) with three replications and will be evaluated in 2014 DS.

- For the BLUP nursery, a total of 98 crosses were generated. This will be tested together with 44 parents (10 B lines and 39 R lines, with some parents included in BLUP and combining ability nurseries; and some in BLUP nursery only). The entries will be laid out in RCBD with three replications.

Illumina 384-plex SNP Genotyping

- The CMS and restorer lines were genotyped with 384 genomewide single nucleutide polymorphism (SNP) markers using the Illumina BeadXpress at IRRI Molecular Marker Applications Laboratory (MMAL). Leaves from 21 day old seedlings were collected and were subjected to DNA extraction, PCR amplification and gel electrophoresis. An aliquot of 5μl from the standardized (50ng/ul) DNA samples were loaded into 96-well plates for the SNP genotyping assay. The Golden Gate Genotyping protocol was used to assay the sample for 2 days. On the second day, the amplified PCR products were hybridized to the Veracode beads in the Illumina bead plate. Scan results were generated from the BeadXpress Reader (http://www.illumina.com/system/beadxpress.ilmn). Alelle calls were generated through the GenomeStudio software and were corrected through ALCHEMY software (Wright et al., 2010). Final allele calls were formatted for different software formats for downstream analysis.

Diversity Analysis

- Using powermarker and the mega software, a phylogenetic tree was constructed from the SNP genotype data. The maintainer lines (red) clustered on the upper part of the tree with at least 2 groups. The restorer lines were in the lower part of the tree with two groups also. Some restorer lines were also interspered in the 2 B-line groups as indicated in the blue lines within the cluster of mostly maintainer lines (red).

Table 35. Generated A x R paired crosses in BLUP and combining ability nurseries.

Restorer lines	PR2A	PR15A	PR20A	IR73328A	IR80151A	IR79128A	IR68897A	IR58025A	IR80156A	IR80559A
IR72889-69-2-2-2R	?	?	?	?					?	?
PR44576-HY-R		?	?							
PR44579-HY-R			?		?			?	?	
PR36246-HY-1-19-2-2R	?	?	?		?				?	
C7324WH-13-1-1-3-2-1R	?	?	?	?	?	?		?	?	?
Matatag 2-25kr-63-4-3-2R		?	?	?	?	?	?		?	?
RB100	?	?	?	?	?			?	?	?
PR34302R	?	?	?	?	?		?	?	?	?
PR36240-HY-1-1-2-2-3-2R	?	?		?	?		?		?	
PR31559-AR32-4-3-2R	?	?	?	?	?	?	?		?	?
PR35749-HY-R		?	?		?	?	?	?	?	?
PR36248-HY-2-5-1R		?	?	?	?	?	?	?	?	?
PR44569-HY-R	?	?					?		?	?
PR34142-5-3-2R	?	?	?	?					?	
AC-66-1R		?		?	?	?			?	
IR73885-1-4-3-2-1-10R	?	?	?	?	?				?	
PR31885-3-1R		?		?	?	?		?		?
PR26134-10-1-1-3-1-2R		?		?	?				?	?
PR36414-HY-1-1-2-1-1-2R		?		?					?	
DT271	?			?						
PR44585-HY-R		?		?					?	
SRT-3R	?	?	?	?					?	?
IR72878-101-2-3-3R				?						
PR36244-HY-1-10R		?			?	?			?	
IR63881-49-2-1-3-3R		?			?	?				?
PR36408-HY-1-2-3-1-2-1R						?				
IR73012-137-2-2-2R					?				?	?
PR44514-HY-R	?									
PR44583-HY-R	?	?	?		?		?			?
IR68019-34-2R	?	?	?							
PR44567-HY-R	?								?	
B77	?								?	
IR73013-95-1-3-2R	?									
PR36419-HY-1-2-4-1-2-2R		?	?							
PR37789-B-1-1-1R		?								?
PR29253-HY-1-1-1-3-1R		?								
IR78566-1-2-1-2R			?							
PR36408-HY-1-2-3-1-2-1R									?	
IR60192-93-3-2-3-3R				?						

Table 36. Generated A x R paired crosses in the combining ability nursery.

No	Restorer lines	PR20A	PR15A	IR79128A	IR73328A	IR80151A	IR80559A
1	C7324WH-13-1-1-3-2-1R	?		?	?	?	?
2	Matatag 2-25kr-63-4-3-2R	?	?	?	?	?	?
3	RB100	?	?	?	?	?	?
4	PR34302R		?		?	?	?
5	PR31559-AR32-4-3-2R	?		?			
6	PR35749-HY-R	?		?			
7	PR36248-HY-2-5-1R	?			?	?	
8	PR26134-10-1-1-3-1-2R		?		?	?	?

Figure 18. A × R paired crossing in hybridization cages on 2013WS

Genetic improvement of parental lines for abiotic and biotic stress
IG Pacada, NV Desamero, LM Perez,EH Bandonill and DAA Tabanao

Rice hybrids are known to have more tolerance to abiotic stress because of their genetic plasticity. Experimental evidence showed the potential adaptability of F1 hybrids under different abiotic stress condition such as salinity. A fundamental activity for developing hybrids suitable for this environment is the breeding and improvement of parent lines adaptive to saline environment.

Due to the vulnerability of parent lines, particularly the cytoplasmic male sterile (CMS) and its maintainer to bacterial blight (BLB) disease, continous development and improvement should be carried out.
The breeding and improvement of parent lines, both abiotic and biotic stress will be useless if the natural outcrossing rate of cytoplasmic male sterile (CMS) line will not improve. Thus, aside from the development of restorer and maintainer lines for salinity environement and improvement of maintainer lines for bacterial blight resistance, the developed maintainer lines should also have good flowering traits that will enhance the total outcrossing rate or seed set of CMS lines.

Highlights:

- Twenty three potential donors were identified for having good flowering behavior, very feathery and well-exerted stigmas.

- Variable reaction of salinity tolerance was observed in evaluated parent lines. The analysis is still in progress.

- Thirty eight advance lines developed with one, two, & three resistance genes -(Xa4;xa5;Xa4+xa5;Xa4+Xa7;xa5+Xa7;Xa 4+xa5+Xa7). Most of these advance lines has excellent grain quality.

- The newly developed BLB resistant lines undergo CMS conversion. The first generation progenies (BC1F1) with different cytoplasmic source were observed to have complete sterility with unstained withered sterile pollen morphology. The evaluated percent natural outcrossing rate showed 30 to 50.

V. Development of Improved Thermo-Sensitive Genetic Male Sterile (TGMS) Lines and TGMS-Based Two-Line Hybrids

SH Escamos

The discovery of TGMS in rice provided new avenues to further exploit heterosis using the two-line system. TGMS are genic male sterile genotypes whose fertility/sterility behavior is conditioned by temperature regimes (Virmani, 1996). This system is useful in the Philippines where temperature differences exist due to elevation, latitude and time of year. The increased chances of finding high yielding hybrids and the more straightforward seed production of TGMS lines makes this system more economically viable.

With the release by the National Seed Industry Council (NSIC) of 2 TGMS-based hybrid rice varieties, the collaborative project between UPLB and PhilRice has demonstrated that breeding and use of TGMS lines to develop two-line hybrids can be successfully done in the Philippines. The project is aimed at developing stable and improved TGMS lines with added focus on earliness and shorter stature. Likewise, it aims to develop two-line hybrids with at least 15% yield advantage over the best inbred variety, pest resistant and with acceptable grain and eating qualities. Earliness, shorter stature and lodging resistance are emphasized in developing new hybrids.

Development of new and diverse TGMS lines through hybridization and selection

SH Escamos, MAT Talavera and TM Masajo

To keep up with the challenge of developing better two-line hybrids, continuous development of new and more improved TGMS lines is an essential component that needs to be pursued. The objective of the study is to develop new and diverse TGMS lines through hybridization and selection. Early-maturing and shorter stature, resistance to pests and diseases and good grain quality are some criteria considered in selection. A TGMS line with low critical fertility point is also considered to ensure safe and successful production of pure F1 seeds at MSE.

Highlights:

- Research activities on the development of new improved and stable TGMS lines through hybridization and selection at both male sterile environment (MSE) and male fertile environment (MFE) were continued during the season.

- At MSE (Los Banos), TGMS lines and pollen parents were assembled and planted for making crosses. Also planted were 46 F1s, 32 F2 populations and 1619 lines in the F3-F7 generation. Thirty (30) F1 populations were selected for advancing to the F2 generation. From the 33 F2 populations grown during the season, 1,111 plants (629 sterile and 482 fertile) were selected. The sterile plants were lifted and brought to MFE (Majayjay, Laguna) for further testing and to produce seeds while fertile selections will be evaluated as F3 lines at MSE during the 2014 dry season. Meanwhile, 390 male sterile plants from the pedigree nurseries (F3 to F6) were also selected and likewise brought to Majayjay, Laguna for further evaluation and seed increase.

- At MFE (Tublay, Benguet), planted during the period were 725 male sterile selections in the generations from F2-F6 Selected and harvested were 605 plants for testing in pedigree nurseries at MSE in 2014 dry season.

- Ten (10) male sterile lines selected in the F6 and F7 were included in the TGMS observation nursery at MSE for evaluation of stability of sterility this 2013 wet season. Five lines were completely male sterile and of good phenotypic acceptability and will be evaluated and seed increased at MFE (Majayjay, Laguna). Also, at MFE (Tublay, Benguet), during the period, 9 advance TGMS lines were also grown for seed multiplication.

Development of new and diverse TGMS lines through recurrent selection
JC Descalsota and TMMasajo

To reinforce TGMS breeding work at PhilRice Los Baños, an initiative to develop TGMS lines through recurrent selection was added. Recurrent selection as a breeding method is generally used in cross-pollinated crops but could also be employed in self-pollinated crops like rice using genetic male sterility system to facilitate natural cross pollination. The main purpose of the method is to concentrate on fewer individuals in the population desirable traits through recurrent cycles of intercrossing and selection. Compared to the generally used hybridization and pedigree selection, intercrossing among individuals in recurrent selection keeps plants in heterozygous conditions allowing for more chances of genetic recombination.

Highlights:

- A total of 765 plants were selected from the 571 F2 populations established in the 2013 wet season pedigree nursery at MSE site for evaluation and selection. Likewise, 260 plants (180 male sterile and 80 fertile plants) were selected from the727 lines planted in the F3. All male sterile plant selections were ratooned, lifted and brought to Majayjay, Laguna for evaluation and seed multiplication.

Identification and development of pollen parents for two-line hybrids

MAT Talavera and TM Masajo

Essential to hybrid development programs for both two-line and three-line system is the availability and identification of potentially good-performing pollen parents. Characters such as yield, plant height, lodging resistance, maturity, resistance to pest and diseases, grain acceptability, tolerance to abiotic stresses, and pollen–shedding ability are traits considered in the selection of pollen parents. Drawing pollen parents from existing inbred variety development programs has been the common practice in hybrid breeding. But lately, with growing interest on hybrids and increased demand for pollen parents, finding suitable and diverse inbreds as male parents of hybrids has become increasingly difficult. Furthermore, access and use of improved germplasm developed and introduced from elsewhere are covered by PVP and MTA and provisions therein could be rather restrictive. While the TGMS project at Los Banos will continue to identify and source pollen parents from available materials, it is doing breeding work purposely to develop better pollen parents for TGMS hybrids.

Highlights:

- For evaluation and identification of superior pollen parents, a total of 532 F2 populations, 347 F3, 2 F4 and 111 lines in the F5 were established during the 2013 wet season in pedigree nurseries. Out of these entries, 640 plants in the F2, 121 in the F3, and 29 in the F5 were selected for advancement and evaluation. One out of the 2 entries in the F4 was selected. This entry was derived from the purple base backcross population.

- Two highly selected TGMS hybrid pollen parents (TG101M and TG102M) are being morphologically tagged with purple coloration at the leaf sheath base through backcrossing.

- Four (4) BC6 crosses using TG101M as recurrent parent 6 using TG102M as recurrent parent were planted. F1s of testcrosses with the TGMS parents were also raised for evaluation. Also, test crosses with PRUP TG101 and PRUP TG102 were made from each of the selected BC5s to evaluate these selected backcross progenies.

Development of two-line experimental hybrids
SH Escamos, MAT Talavera and TM Masajo

In order to find good performing hybrids, test cross of the TGMS lines with as many and as diverse pollen parents available is necessary. Not all hybrids exhibit positive heterosis for economic traits, hence there is a need to produce a large number of experimental hybrids for testing and evaluation. The objective of the study is to generate as many experimental hybrids as possible to increase the chances of finding heterotic hybrids.

Highlights:

- Two-line experimental hybrids were generated through hand-crossing using 15 promising TGMS lines and 86 pollen parents. Promising lines from the NCT, the UPLB breeding nurseries, NSIC released varieties and wide hybridization-derived lines were used as male parents.

- One hundred sixty (160) new experimental hybrids with sufficient seeds were produced during the season. Performance of these new hybrids was evaluated in the 2013 wet season hybrid observation nursery.

Evaluation and field performance testing of promising hybrids
DJ Lalican, MAT Talavera, SH Escamos and TM Masajo

Before a hybrid can be nominated to the NCT, it has to pass a series of evaluation and testing to determine its overall performance. The experimental hybrids have to undergo testing in the Hybrid Observational Nursery (HON) to initially eliminate inferior performing hybrids. Selected hybrids are elevated to the preliminary yield trial and advance yield trial for a more thorough evaluation for yield, insect and disease reaction and grain and milling qualities. Promising hybrids are channeled to multi-location and yield potential trials.

The objective is to evaluate the performance of experimental hybrids and identify and select the best performing hybrids that can be channeled to the National Cooperative Tests.

Highlights:

- One hundred sixty (160) experimental hybrids were evaluated in the Hybrid Observational Nursery (HON) during the season using Mestiso 19 and Mestiso 20 as hybrid checks, and PSB Rc82 and NSIC Rc222 as inbred check varieties. Seventeen (17) hybrids were identified better than the higher yielding inbred check NSIC Rc222. Fifteen (15) out 17 hybrids yielded more than one ton higher than the higher yielding inbred check. F1 seeds of these hybrids will be produced this 2014 dry season for further testing in the hybrid preliminary yield trial (HPYT). The performance of some good performing hybrids is shown in Table 37. HON gave the highest yield (9609 kg/ha) followed by HON (8931kg/ha). Preliminary evaluation of grain quality in terms of amylose and gel temperature was also conducted.

- In the hybrid preliminary yield trial (HPYT), 32 two-line hybrids were evaluated during the season. Four hybrids were identified more superior than the best inbred check (NSIC Rc 222) yielding more than one ton higher. Highest yield obtained was 6044kg/ha with a yield advantage of 76.7% over PSB Rc82 and 23.3% over NSIC Rc222 (Table 38).

- Eight (8) promising hybrids comprised the advance yield trial conducted during the season. HAYT 88 which gave the highest yield (5938kg/ha) and a yield advantage of 15.2% over NSIC Rc222 (Table 39). F1 seeds of this hybrid will be produced this wet season in preparation for entry to multi-location trials and eventually to the National Cooperative Test (NCT).

Promising hybrids entered in NCT and multi-location trials

- One (1) promising hybrid designated as PRUP 10 was entered in the 2013 wet season trial of the NCT. This hybrid had a yield advantage of 29.5% over PSB Rc82, medium maturing and grows to a height of around 108 cms.

- Three (3) good performing early-maturing hybrids will be entered in the multi-location trials being conducted by PhilRice in the 2014 DS.

Table 37. Yield and agronomic traits of good performing hybrids in the hybrid observation nursery, 2013 WS.

Index No.	Grain Yield (kg/ha)	% YA over PSB Rc82	% YA over PSB Rc222	Maturity (days)	Tiller/hill (no)	Plant height (cm)
HON 133	7341	104.2	60.1	128	17	111
HON 41	6837	90.2	49.1	117	12	100
HON 173	6693	86.2	45.9	126	12	117
HON 28	6287	74.8	37.1	122	8	106
HON 9	6165	74.8	34.0	124	13	112
NSIC Rc222	4586	-	-			
PSB Rc82	3595	-	-			
M19	4729	-	-			
M20	4689	-	-			

Table 38. Yield and agronomic traits of some good hybrids in the preliminary yield trial, 2013 WS.

Index No	Grain Yield (kg/ha)	% YA over PSB Rc 82	% YA over NSIC Rc 222	Maturity (days)	Plant height (cm)	Tiller/hill (no)
HPYT 382	6044	76.7	23.3	88	96	15
HPYT 384	5890	72.17	20.2	88	100	14
HPYT 406	5846	70.8	19.0	87	103	15
HPYT 386	5793	69.3	18.0	90	108	11
NSIC Rc 222	4902	-	-	-	-	-
PSB Rc 82	3421	-	-	-	-	-
M19	5363	-	-	-	-	-
M20	4602	-	-	-	-	-

Table 39. Yield and other agronomic traits of promising hybrids in the advance yield trial, 2013WS.

Entry	Grain Yield (kg/ha)	% YA over PSB Rc 82	% YA over NSIC Rc 222	Maturity	Tiller No	Height (cm)
HAYT	5938	74.2	15.2	121	108	12
HAYT	5277	54.8	2.4	122	100	11
HAYT	5211	52.9	1.5	118	102	10
HAYT	5193	52.3	.01	122	109	10
NSIC Rc 222	5154	-	-			
PSB Rc 82	3409	-	-			
Mestiso 19	5766	-	-			
Mestiso 20	5156	-	-			

Development of aromatic, glutinous, pigmented and iron/zinc-dense rice varieties

EC Arocena, KB Geneston, JA Orcino, GM Osoteo, RC Braceros and AQC Sabanal

Aromatic, glutinous and pigmented rice commands higher price in the market. However, low yield, susceptibility to pests, unstable and occasion-driven demand of these rices limits its wide cultivation. Another challenge posed to rice breeders is the improvement on the micronutrient content of the rice grain. Micronutrient malnutrition specifically iron deficiency anemia (IDA) among children, pregnant and lactating women and Vitamin A deficiency are the most prevalent in the country. The Philippine Government exerted efforts to eliminate the iron malnutrition problem in the country by artificially enriching milled rice with iron and vitamin A supplementation. These efforts however, entail a lot of resources and do not guarantee that the afflicted people in the rural areas are reached by these fortified products.

Breeding objectives therefore, are geared towards increasing productivity without altering the specific specialty characters to lure the farmers to expand its cultivation. Consequently, farmer's productivity will increase as well as those of the small scale entrepreneurs solely dependent on the availability of these varieties. Furthermore, they will be globally competitive if available high quality rices are acceptable to the world market. Breeding strategy for micronutrient enhancement of rice also holds a great promise for making a significant, low-cost, and sustainable contribution to reducing micronutrient malnutrition.

Highlights:

Line development

Line development starts with the selection of parental to the generation of crosses and subsequently selection of desirable plants from the segregating generations. Breeding efforts during the season resulted to;

- A total of 70 parentals with the desired specialty characteristics, yield enhancing traits and pest resistance specifically blast, BLB and tungro were utilized for crossing.

- Generated 56 new crosses, 26 combinations for aroma (A), 5 glutinous (G), 10 pigmented (P) and 15 for high grain iron/ zinc content (Fe). Pollen source was limited due to frequent rain and cloudiness, hence, resulted to sterility and poor seed setting.

- In the F1 nursery, out of the 102 crosses planted, 10A, 25G, 14P and 11Fe crosses were selected for generation advancement while 8Fe crosses were selected for single plant selection. The rest were kept in the cold storage for 2014 WS planting

- From the hybrid population for non-selection, 16A, 9G, and 10P crosses were selected for single plant selection. From the 40 hybrid populations planted for selection (HPS), 3253 plants were selected in the field which was reduced to 1360 after kernel evaluation. Fig. 1 shows the number desirable lines selected in the HPS per category.

- From the pedigree nursery (PN), out of the 2056 lines planted, field selection identified 1156 lines for further line selection while 465 lines for advancement to AON. However, after kernel evaluation, these were reduced to 502 lines for pedigree nursery and 210 lines for AON which was segregated per category as shown in Fig. 19.

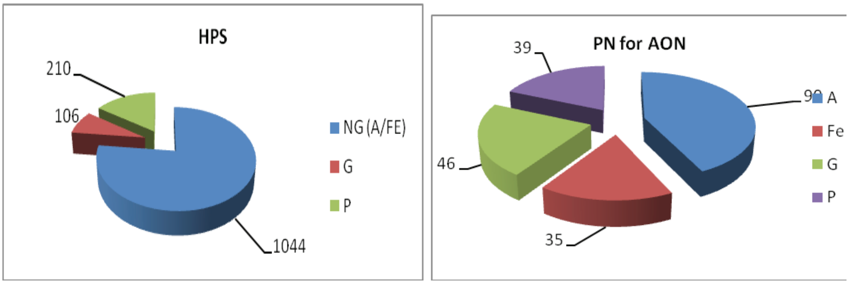


Figure 19. Selected uniform lines in the HPS and PN for AON segregated per category

Emphasis on kernel quality evaluation was done to segregate the selected lines per kernel types. Fig 20 shows the number of selected lines in the HPS and PN per kernel types. Majority of the selected lines had good to excellent kernel quality. Fair kernel quality was considered owing to the good panicle type and ripening color of the leaves of the these selected lines.

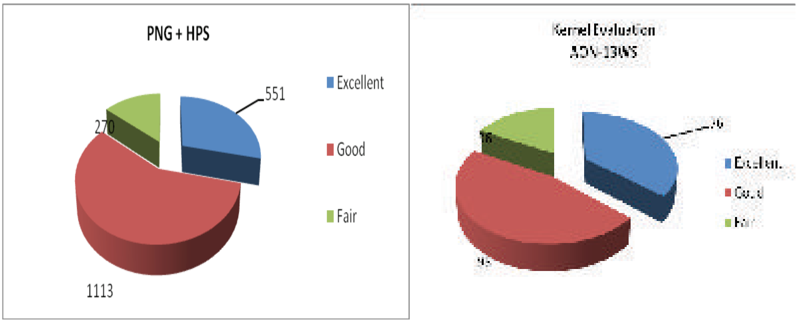


Figure 20. Kernel quality types of the selected lines in the HPS and PN, 2013WS

Elite lines in the performance trials

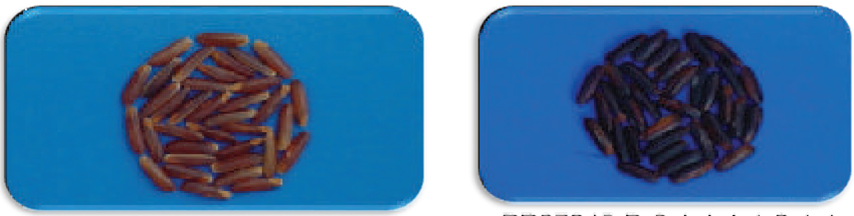
- In the Advanced Observation nursery (AON), out of the 366 test entries planted, 135 entries were retained for further testing in the nursery. There were 8A, 2G and 1P elevated to multi-environment test (MET) while 15A, 7Fe, 12G and 3P test entries were advanced to PYT. Notable were the test entries with more than 5t/ha yield despite the effect of typhoons Santi and Yolanda (Table 40).

Table 40. Yield performance of the test entries elevated to PYT and MET0 in the AON.

Entries planted	Retained	Elevated to PYT	Elevated to MET 0	Yield of elevated entries	Yield of Check Variety	Remarks
Aromatic = 255	40	15	8	3838-6125kg/ha	NSIC Rc128 5380kg/ha	Lines with lower yields than the check were selected but with aroma
Fe = 31	26	7	-	3450-5419kg/ha	PSB Rc82 3337kg/ha	
Glutinous = 41	13	12	2	3675-4825kg/ha	NSIC Rc13 3031kg/ha	
Pigmented= 39	21	3	1	3213-5625kg/ha	NSIC Rc19 3065kg/ha	
Total 366	**135**	**43**	**11**			

- Similarly, in the Preliminary Yield Trial (PYT) yield performance of the test entries were affected by the typhoons. However, highest yields attained per category ranged from 4.1t/ha to 5.5t/ha. The aromatic entries recorded the highest yields as compared to other groups (Table 41).

  - Two promising pigmented lines were seed increased for possible plant variety protection (PVP) awaiting NCT evaluation owing to its good sensory characteristics and suitability to brown rice (Figure 21).



PR35034-B-3-2-1-1-4-1-2-1-1-2-1 PR37045-B-6-1-1-1-1-2-1-1

Figure 21. Dehulled grains of the promising pigmented lines suitable for brown rice.

Table 41. Yield performance of the test entries in the PYT.

Entries planted		Retained	Potential MET entries	Yield Range	Check Variety	Remarks
Aromatic	**= 89**	58	27	2765-5491kg/ha	NSIC Rc128 2888kg/ha	Yields were affected by typhoons Santi and Yolanda
Fe	**= 25**	17		2410-4756kg/ha	PSB Rc82 2130kg/ha	
Glutinous	**= 13**	6		2627-4135kg/ha	NSIC Rc13 3023kg/ha	
Pigmented	**= 16**	11	1	2657-4150kg/ha	NSIC Rc19 3970kg/ha	
Total	**143**	**92**	**28**			

Elite lines in the multi-location evaluation trials

- The National Cooperative Tests (NCT) was affected by typhoons Santi and Yolanda, hence, low yields were recorded by the test entries.
  Among aromatic group, none of the test entries outyielded NSIC Rc128 (5566kg/ha), the yield check and Burdagol (4931kg/ha), the aroma check. PR37343-B-6-3-2-2-2 (4528kg/ha and PR38949-B-29-2 (4482kg/ha) produced more than 4000kg/ha.

  Similarly, the two checks, NSIC Rc13 (4906 kg/ha and NSIC Rc15 (4697 kg/ha) outperformed the test entries. Only PR38948-B-51-1-1 produced 4534kg/ha, the best among the test entries.

Aside from the effects of typhoons, moderate to severe reactions to bacterials leaf blight and stemborer were exhibited by the entries.

- In the Multi-Environment Trial (MET), five lines were among the top performers with yields ranging from 6-7t/ha. Two entries were among the top ten in the overall ranking and in yield stability index (Table 42). These entries are potential entries for NCT.

Table 42. Performance of the special purpose promising lines in MET.

MET No.	Designation	Yield (t/ha)	Overall Rank	ASV Rank	YSI Rank
MT5997	PR38168-2B-3-1-3-1-1-1-2	7	8	16	5
MT5999	PR38963 (Fe)-B-5-4-2-1-1	6.9	9	31	8
MT5995	PR41588-JR-B-B-78	6.4	38	20	14
MT5998	PR38991 (Fe)-B-17-1-1	6.2	59	25	31
MT5996	PR38952-B-22-3-2	6.1	71	110	99

Production of golden rice introgression lines in the background of selected popular varieties

AA Alfonso, EO Espejo, RT Miranda, ES Avellanoza, KJB Panaligan and CFS Te

Golden Rice (GR) is a type of rice that expresses functional Phytoene synthase (psy) and Phytoene desaturase (crt1) genes in the endosperm, resulting in the accumulation of betacarotene (provitamin A) in the grain and giving it a yellow-orange color. This is being eyed as an additional strategy to combat vitamin-A deficiency (VAD), which is a prevalent form of micronutrient malnutrition in the Philippines. This study aims to transfer the betacarotene biosynthetic genes from GR2R (genetic background of PSB Rc82, with up to 37 ug betacarotene per gram of rice) into popular Philippine rice varieties, PSB Rc82, NSIC Rc160, NSIC Rc216 and NSIC Rc222. The acceptable morpho-agronomic traits of these varieties increase the likelihood of acceptance by the farmers. Also, the use of molecular markers will help ensure recovery of the genetic constitution of the recurrent parents.

Highlights:

- Nine populations of PSB Rc82 x GR2R BC3F5 plants were further evaluated inside the CL2 screenhouse on 13DS. Of the nine lines evaluated, PSB Rc82xGR2-R-B3-117-10-3-33-12 was selected which is homozygous to golden rice locus and with yellow seeds (Table 43). Out of the 67 plants evaluated from this line, 64 were homozygous to the GR locus while three plants were heterozygous. These three plants are taller than the wildtype (average of 116 cm) and had good panicle exertion. The rest of the eight populations had a plant height that is comparable to the wildtype but majority of them are heterozygous.

- On the onset of 13DS, the breeder team agreed that plants for further line development of PSB Rc82-GR2-R be identified (Table 44). Out of these five plants, PSB Rc82xGR2-R-B3-162-3-25-3-06-90-31 was identified to be of priority for hybridization due to its high betacarotene content (IRRI data). Nevertheless, hybridization of the remaining plants was still conducted as back-up materials and generated BC4F1 seeds.

- During 2013 WS, PSB Rc82xGR2-R-B3-117-10-3-33-12 was selected and brought to Golden Rice multi-location trial site at Muñoz for planting under field condition and for further backcrossing. This is to recover genes from recurrent parent for further line improvement.

- Introgression of GR2R into popular Philippine varieties was also conducted. In 2013 dry season, 7 BC3F1 of GR2R x NSICRc160, 8 BC3F1 of GR2R x NSIC Rc222 and 14 BC2F1 of GR2R x NSICRc216 were generated from backcrossing to recurrent parents. A total of 6 plants were selected with homozygous Golden Rice allele; 1 BC4F1 plant from GR2R x NSICRc160, 2 BC4F1 from GR2R x NSIC Rc222, and 3 BC3F1 plants from GR2R x NSICRc216. Seeds from these cross combinations were planted and characterized the following season.

- During the 2013 wet season, one selected BC4F1 plant of GR2R x NSIC Rc160 was seed increased and produced 10 BC4F2 plants. Two selected BC4F1 plants of GR2R x NSIC Rc222 were also advanced and have 16 BC4F2 plants. On the other hand, three selected BC3F1 plants of GR2R x NSIC Rc216 were forwarded to BC3F2. Further backcrossing to the three recurrent parents was done to generate both BC5F1 and BC4F1 seeds. Table 45 shows the generated crosses from backcrossing the recurrent parents for 2013.

Table 43. Selected plants of PSB Rc82-GR2-R materials as candidates for backcrossing to the recurrent parent for BC4F1 seed production.

Pedigree	Generation	Plant height (cm)	Days to flowering	Maturity	Panicle exertion	Productive tillers	Foreground Data	Grain color	Segregation Ratio (Y:W)
PSB Rc82 x GR2-R-B3-117-1-10-3-14-46	BC_3F_4	107	76	106	7	7	GR2R locus	Segregating	75:25:00
PSB Rc82 x GR2-R-B3-117-1-10-3-14-66	BC_3F_4	100	77	107	9	7	GR2R locus	Segregating	37:13:00
PSB Rc82 x GR2-R-B3-117-1-10-3-14-161	BC_3F_4	96	76	106	7	7	GR2R locus	Segregating	60:20:00
PSB Rc82 x GR2-R-B3-117-1-10-3-33-12	BC_3F_4	102	74	104	5	8	GR2R locus	Yellow	60:00:00
PSB Rc82 x GR2-R-B3-162-3-26-1-19-156	BC_3F_4	117	77	107	5	10	GR2R locus	Segregating	63:17:00
PSB Rc82 x GR2-R-B3-162-3-26-1-19-162	BC_3F_4	126	77	107	5	6	GR2R locus	Segregating	45:05:00
PSB Rc82 x GR2-R-B3-162-3-26-1-19-164	BC_3F_4	119	77	107	7	9	GR2R locus	Segregating	74:16:00
PSB Rc82 x GR2-R-B3-162-3-26-1-19-171	BC_3F_4	121	74	104	5	5	GR2R locus	Segregating	42:08:00
PSB Rc82 x GR2-R-B3-162-3-26-1-19-174	BC_3F_4	122	74	104	5	9	GR2R locus	Segregating	73:27:00

Table 44. PSB Rc82-GR2-R materials identified for further line development.

Pedigree	Generation	Source
PSB Rc82xGR2-R-B3-162-3-25-3-06-73-69	BC_3F_6	IRRI
PSB Rc82xGR2-R-B3-162-3-25-3-06-73-16	BC_3F_6	IRRI
PSB Rc82xGR2-R-B3-162-3-25-3-06-90-16	BC_3F_6	IRRI
PSB Rc82xGR2-R-B3-162-3-25-3-06-90-31	BC_3F_6	IRRI
PSB Rc82xGR2-R-B3-117-1-10-3-24-78-7	BC_3F_6	IRRI
PSB Rc82xGR2-R-B3-117-1-10-3-33-12	BC_3F_5	PhilRice

Table 45. Crosses made for Golden Rice introgressed to selected popular local varieties, 2013 DS and WS.

Cross combination	Generation	Cropping Season
GR2-R x NSIC Rc160	BC_4F_1	13DS
GR2-R x NSIC Rc222	BC_4F_1	13DS
GR2-R x NSIC Rc216	BC_3F_1	13DS
GR2-R x NSIC Rc160	BC_5F_1	13WS
GR2-R x NSIC Rc222	BC_5F_1	13WS
GR2-R x NSIC Rc216	BC_4F_1	13WS

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

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PhilRice Central Experiment Station
Science City of Muñoz, 3119 Nueva Ecija
TRUNKLINES: 63 (44) 456-0277, -0258, 0285
Direct Line/Telefax: (044) 456-0112
prri.mail@philrice.gov.ph

PhilRice Agusan
Basilisa, RTR Romualdez, 8611 Agusan del Norte
Tel: (085) 343-0778
Telefax: (085) 343-0768
agusan.station@philrice.gov.ph

PhilRice Batac
MMSU Campus, Batac City, 2906 Ilocos Norte
Tel: (077) 670-1867
Telefax: (077) 792-4702, -2544
batac.station@philrice.gov.ph

PhilRice Bicol
Batang, Ligao City, 4504 Albay
Mobile: 0906-935-8560; 0918-946-7439
bicol.station@philrice.gov.ph

PhilRice Isabela
San Mateo, 3318 Isabela
Tel: (078) 664-2954
Telefax: (078) 664-2953
isabela.station@philrice.gov.ph

PhilRice Los Baños
UPLB Campus, College, 4031 Laguna
Tel: (049) 501-1917
Telefax: (049) 536-8620
losbanos.station@philrice.gov.ph

PhilRice Midsayap
Bual Norte, Midsayap, 9410 North Cotabato
Tel: (064) 229-8178
Telefax: (064) 229-7242
midsayap.station@philrice.gov.ph

PhilRice Negros
Cansilayan, Murcia, 6129 Negros Occidental
Mobile: 0928-506-0515
negros.station@philrice.gov.ph

PhilRice Field Office
CMU Campus, Maramag, 8714 Bukidnon
Tel: (088) 222-5744

PhilRice Liason Office
3rd Flr. ATI Bldg, Elliptical Road
Diliman, Quezon City
Tel/Fax: (02) 920-5129
Mobile: 0920-906-9052

PhilRice Text Center
0920 911 1398

PhilRice Website
www.philrice.gov.ph

PhilRice Website
www.pinoyrkb.com

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