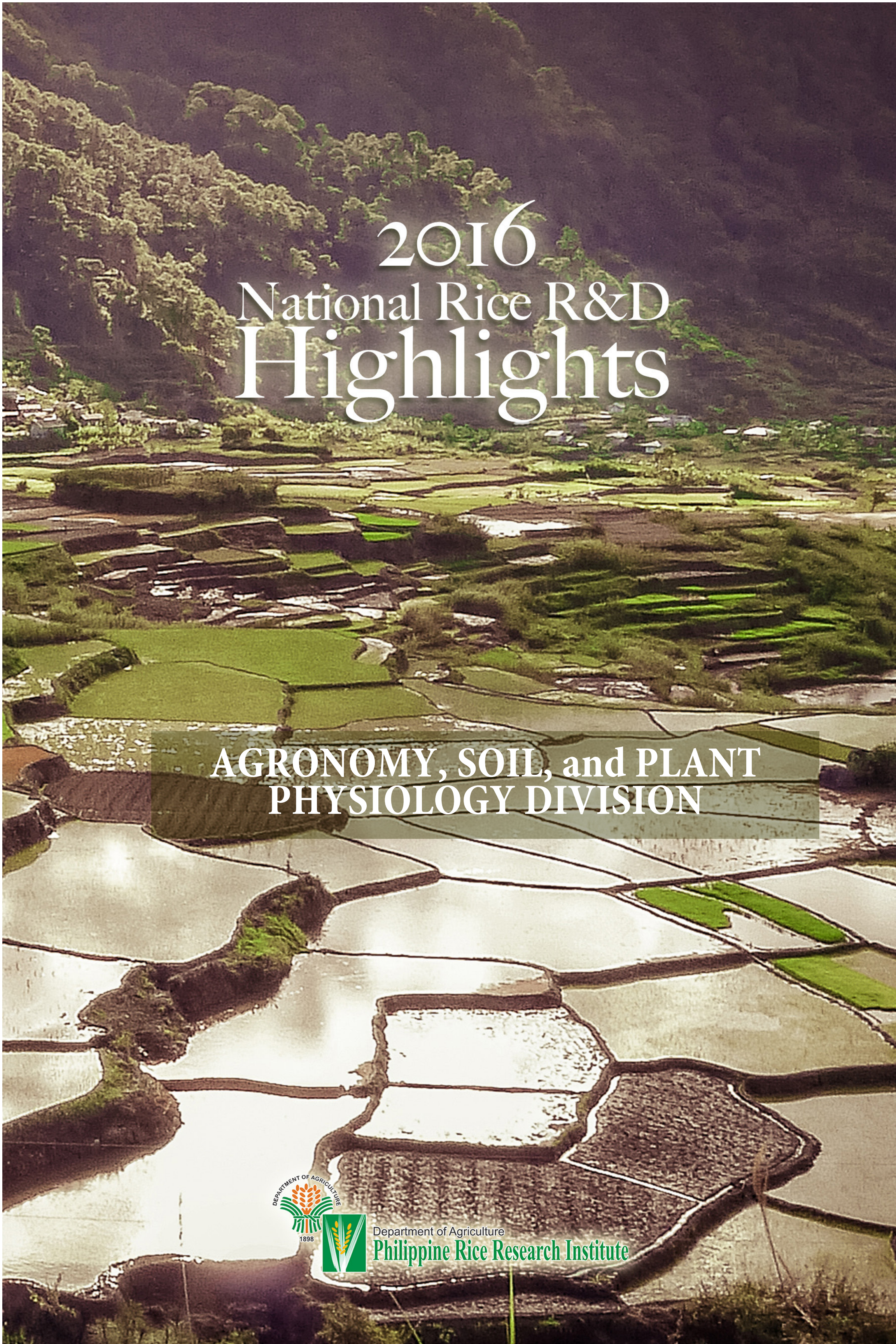

2016 National Rice R&D Highlights

AGRONOMY, SOIL, and PLANT PHYSIOLOGY DIVISION

DEPARTMENT OF AGRICULTURE 1898
Department of Agriculture
Philippine Rice Research Institute

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Agronomy, Soils, and Plant Physiology Division

Division Head: Leylani M. Juliano

Executive Summary

The division leads national efforts in the conduct of quality research focused toward identifying, evaluating, refining, and facilitating delivery of improved soil, plant, nutrient, and water management practices that are resource-use efficient and environment-friendly for rice and rice-based ecosystems. This major final output should be able to contribute to the goal of PhilRice in helping attain and sustain rice self-sufficiency. The goal is to package technologies to increase yield by 15% in less productive environments and sustain yield in high-yielding environments. The functional objectives are identified based on the specific tasks assigned to the division: (1) identify and propagate approaches for nutrient and crop management with the integration of management of principal insect pests and disease; (2) develop technologies that will improve soil and water conservation practices; (3) develop practices to manage crop residues for healthy soils in rice ecosystems; (4) strengthen the scientific basis for rice-based cropping system technologies; and (5) assess the impact of developed technologies on environmental quality. Finally, the division is expected to develop crop management protocol, diagnostic tools, and processes toward sufficiency and sustainability.

Starting 2016, seven (7) research thematic projects and a project on laboratory management were implemented to partially approach the main objective of the Division. These projects were (1) Assessment of soil fertility, plant, water and nutrient management including plant responses, (2) Development and assessment of soils, water, and nutrient diagnostic tools, (3) Assessment and evaluation of crop intensification and resource use efficiency in rice production, (4) Assessment and evaluation of variety, water, nutrient and pest interactions, (5) Development of crop management practice for stress environments, (6) Soil health, water quality and availability, (7) Nutrient and pest interactions; and to support these activities is the ASPPD research and analytical laboratory systems and maintenance. Under these projects are 18 studies implemented at CES, branch stations, and on-farm.

Highest dry season grain yield of 10.1 t ha-1 was obtained in the on-farm trial with the application of pure inorganic fertilizers in Pangasinan following the Rice Crop Manager (RCM) recommendation. On the other hand, highest on-station grain yield of 7.13t ha-1 was obtained with LCC-based N application of 151kg ha-1, and 5.16t ha-1 with pure organic fertilizer. Highest yield of 4.60t ha-1 was obtained by NSIC Rc160 at PhilRice CES without fertilizer application. In terms of efficiency of applied N, the application of pure inorganic fertilizers showed higher AEN (26.3kg grain kg-1 N) than with pure organic fertilizers (15.6kg grain kg-1 N). Further, AEN

using chicken manure is 26.38kg grain kg-1 N and azolla has 3.5kg grain kg-1 N applied.The LCC-based N application also produced more grains per unit of N applied (21.1kg grain kg-1 N) in the dry season.

In the wet season, highest grain yield of 8.9t ha-1 was obtained in Sta. Cruz, Laguna following the RCM recommendation. The application of pure organic fertilizers gave an average grain yield of 5.28t ha-1 that was comparable to the unfertilized rice plants. Similar to the dry season, higher AEN was obtained with the application of inorganic fertilizer than the pure organic fertilizers.

The indigenous nutrient supplying (INS) capacities of the long-term soil fertility experiment at PhilRice CES during the 2016 dry season were 77.3kg N ha-1, 13.0kg P ha-1, and 67.0kg K ha-1. The wet season trial was affected by lodging losses due to heavy rains brought by typhoons, hence, no analysis of the INS was done.

The corn-rice-rice cropping on-farm trial showed higher yellow corn grain yield at 9.01t ha-1following the Corn Crop Manager (CCM) recommendation than the farmer's practice. Fertilizer rate of 185-35-65 NPK ha-1 was used in the CCM, while, 236-77-66 NPK ha-1 in the farmer's practice with savings of P3,698.93 per hectare on fertilizer cost (CCM). Thus, higher partial factor productivity (PFPN) from applied nitrogen (N) were achieved by the CCM recommendation than the farmer's practice. For rice, an average of 0.44 t ha-1 rice yield increase was attained over the baseline yield (5.5t ha-1). Partial factor productivity (PFP) for N has a mean difference of 13.14 and 5.65 for corn and rice respectively. Economics of return yielded more at 24% for corn and 14% for rice.

The evaluation of diagnostic tools showed that for DSSAT, crop genetic coefficients for 8 growth stages were generated for PSB Rc82 and Mestiso 20 with the potential yields simulated and compared to observed yields. In the dry season, yields and AEN obtained for LCC-based applied with 112kg N ha-1 were 4.4 to 5.8t ha-1 with AEN of 4.5 to 8.0kg grain kg-1 N applied and for growth stage-based applied with 140kg N ha-1 were 5.2 to 5.5t ha-1 with 1.4 to 3.6kg grain kg-1 N applied. WS data showed that LCC-based 74 kg N ha-1 yields were 5.8 to 6.6t ha-1 (AEN of 3.2 to 21.2kg grain kg-1 N applied) and growth stage-based yield applied with 95kg N ha-1 were 6.1 to 6.4t ha-1 (AEN: 6.5 to 14.3kg grain kg-1 N applied). Comparison of using atLEAF and SPAD showed that atLEAF can be as good as SPAD for normalized difference vegetation index (NDVI) measurements. Based on R2 at different growth stages (early and active tillering, panicle initiation, heading to flowering stage), at PI stage atLEAF has as good prediction estimation as SPAD. Grain yield of fixed N rate (7.2t ha-1) and LCC-based (6.9t ha-1) are higher than SPAD-based (6.4t ha-1) and atLEAF-based (6.2t ha-1). The use of N-rich plot for N requirement and a pocket sensor showed

that grain yield of N-rich plot (7.9t ha-1), 90 kg N/ha + sensor-based (7.3t/ha) and 120 kg N/ha + sensor-based (7.5t/ha) are higher than in the fix-time N treatment (7.2t/ha). The development of alpha version of the LCC android app is 60% completed with the development of processes for extracting Red, Green and Blue (RGB) values from the leaf image; RGB to Hue, Saturation and Brightness (HSB) values conversion; and HSB that will be converted to Dark Green Color Index which will be correlated to the Nitrogen leaf concentration.

The assessment of rice varieties with improved crop management technologies showed that agronomic N-use efficiency (AEN) of the 6 varieties (NSIC Rc160, Rc222, Rc238, Rc240, Rc298 and PSB Rc18 ranged from 18.77 to 26.07kg grain kg N-1 in the dry season (highest for NSIC Rc160) and 8.7 to 23.5kg grain kg N-1 (highest for NSIC Rc298) during the wet season. Water productivity ranged from 0.59 to 1.13kg grain cm^{-3} water with Rc160 having the highest WP in conventional tillage. Interaction between tillage and varieties was significant. On the other hand, yield potential of test varieties (NSIC Rc122, Rc238, Rc240, Rc302, Rc308, Rc360 and checks PSB Rc18 and Rc82) were 5.76 to 7.27t ha-1 in DS and WS yield ranged from 5.21 to 6.14t ha-1 across treatments (5 to 27% increase).. AEN was significantly higher with PalayCheck LCC-based N application (28.20kg grain kg N-1) than the fixed rate and time N application of 190kg N ha-1 (13.03 kg grain kg N-1).Total N rate with PalayCheck LCC-based ranged from 77 to 112kg N ha-1 including the basal N applied from 6 bags 14-14-14-12S or complete fertilizer.

Out of the 12 genotypes screened in controlled conditions, PR41543-B-14-2-1-2 showed higher tolerance to partial flooding (30 and 50cm) comparable to the FR13A check. Other genotypes such as Rc18, Ciherang Ag+Sub1, IR42, Rc194 and Rc82 also showed tolerance to flooding. Field set-up revealed that Ciherang Ag+Sub1 showed higher tolerance to flooding and better yields but comparable to PSB Rc82; significantly higher compared to PR41543-B-14-2-1-2. Of the 3 genotypes and 3 N fertilizer treatments, yields with 30 cm floodwater depth (2.1 to 6.8t ha-1) were higher than yields with 50 cm floodwater depth (1.7 to 4.2t ha-1).

Information on the accumulation of light metals in mine tailings showed that light metals (Zn, Cu, Fe, and Mn) in rice straw were higher than in the grains but lower than maximum allowed limit in plants (WHO/FAO). Further, Zn and Cu were in normal concentration but Fe and Mn high were nearing toxic levels (based on the maximum allowable limit of light metals in plant by WHO/FAO, 2014). Soil Fe was high and twice as much in WS, and high Cu was also found in the soil in WS.

Information on nutrient x pest interaction showed that 221kg N ha-1 produced the highest yield with appropriate ShB and BLB management (50%). Lower BLB severity was observed with inoculation of N2-fixing bacteria; decreasing incidence up to 158kg N ha-1 (50%).

The ASPPD research laboratory achieved preventive maintenance service and calibration of 20 laboratory equipment as scheduled with 6 laboratory equipment repaired. Maintained and updated inventory of incoming and outgoing of chemicals. Submitted 2016 semi-annual report on the requirement of "Permit to Purchase" and "Controlled Precursors and Essential Chemicals" to SPO/PPMD on the procurement and usage of chemical supplies in our research activities controlled by the Philippine Drug Enforcement Agency (PDEA). In terms of capacity building, the Laboratory Manager and another staff participated in the seminar on "Best Practices and Challenges Toward Sustainability in Laboratory Management" spearheaded by Philippine Alliance of Laboratory Equipment Users.

I. Assessment of Soil Fertility, Plant, Water and Nutrient Management

Project Leader: Wilfredo B. Collado

The project implemented four studies during the 2016 dry and wet seasons cropping. Two studies on the long-term effect of inorganic and organic fertilizers on rice and soil fertility (ASD-002-001 and ASD-002-002) were conducted at the PhilRice Central Experiment Station. One on-farm study on the assessment of inherent productivity and fertility of lowland soils (ASD-002-010) was conducted in Laguna (Sta. Cruz), Nueva Ecija (Maligaya) and Pangasinan (San Manuel). The last on-farm study on the determination of a more productive and profitable cropping system (ASD-002-011) was conducted in Balungao, Pangasinan.

Highest dry season grain yield of 10.1t ha-1 was obtained in the on-farm trial with the application of pure inorganic fertilizers in Pangasinan following the Rice Crop Manager (RCM) recommendation. On the other hand, highest on-station grain yield of 7.13t ha-1 was obtained with LCC-based N application of 151kg ha-1, and 5.16 t ha-1 with pure organic fertilizer. Highest yield of 4.60t ha-1 was obtained by NSIC Rc160 at PhilRice CES without fertilizer application. In terms of efficiency of applied N, the application of pure inorganic fertilizers showed higher AEN (26.3kg grain kg-1 N) than with pure organic fertilizers (15.6kg grain kg-1 N). The LCC-based N application also produced more grains per unit of N applied (21.1kg grain kg-1 N) in the dry season.

In the wet season, highest grain yield of 8.9t ha-1 was obtained in Sta. Cruz, Laguna following the Rice Crop Manager recommendation. The application of pure organic fertilizers gave an average grain yield of 5.28 t ha-1 that was comparable to the rice plants that did not received any fertilizer. Similar to the dry season, higher AEN was again obtained by the application of inorganic fertilizer than the pure organic fertilizers.

The indigenous nutrient supplying (INS) capacities of the long-term soil fertility experimental site at PhilRice CES during the 2016 dry season were 77.3 kg N ha-1, 13.0 kg P ha-1, and 67.0kg K ha-1. The wet season trial was affected by lodging losses due to heavy rains brought by typhoons. Thus, no analysis of the INS was done.

In the on-farm trials with a rice-rice cropping system, a positive N balance was observed in most sites, negative P balance in Laguna sites, but positive in Nueva Ecija and Pangasinan, and negative K balance in all sites. Seventy-five percent of the sites were below the optimum pH level, while 67% of the sites have adequate to high levels of organic matter. All sites were deficient in N, 75% deficient in K, 83% deficient in S, and 75% sufficient in Cu and Zn (based on MOET test). Thus, it is recommended that P rates should be increased in Laguna sites, while K rates should be increased in all sites.

The corn-rice-rice cropping on-farm trial showed higher corn grain yield following the Corn Crop Manager (CCM) recommendation than with farmer's practice. Highest yellow corn yield of 9.01t ha-1 was obtained by the CCM recommendation. Fertilizer rate of 185-35-65 NPK ha-1 was used in the CCM, while, 236-77-66 NPK ha-1 in the farmer's practice. A savings of Php 3,698.93 per hectare on fertilizer cost was obtained with CCM. Thus, higher partial factor productivity (PFPN) from applied nitrogen (N) were achieved by the CCM recommendation than the farmer's practice. The CCM recommendation also showed almost the same ear length, ear diameter, and grain weight with the farmer's practice. However, the number of kernels per ear produced across sites was greater in the CCM than the farmer's practice. In the early wet season rice cropping, generally higher average grain yield was obtained across sites following the Rice Crop Manager (RCM) recommendation compared to the farmer's practice (5.94 vs. 5.82 t ha-1). Higher partial factor productivities from applied N across season was obtained from the introduced crop management recommendations. Higher returns on investment from the introduced crop management were generated with an advantage of 28% and 14% over the farmer's practice for corn and rice, respectively.

Long-Term Soil Fertility Experiment

WB Collado and AA Corpuz

The Long-Term Soil Fertility Experiment has been on-going at the Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija since 1968. The study served the purpose of studying the sustainability of intensive double rice cropping and providing an early warning indicator of nutrient imbalances and nutrient mining that can occur with intensification in farmer's fields. The study aimed to achieve high and stable rice production on a sustainable basis in the treatment with full application of nitrogen (N), phosphorus (P) and potassium (K). The treatments with combinations of N, P, and K fertilizer enable an assessment of the long-term nutrient supplying capacity of the soil. The control without N, P and K fertilizer application enables an assessment of the long-term indigenous N-supplying capacity.

Activities:

- Establishment of field experiment to determine the effect of the application of complete and incomplete nutrients on the growth and yield of lowland rice with inorganic fertilizer sources;
- Calculation of the agronomic efficiency of the applied N;
- Determination of the seasonal indigenous nutrient supplying capacity of the site; and
- Collection of soil samples for the assessment of soil fertility.

Results:

Grain Yield

- The 2016 dry season cropping was slightly affected by brown planthopper (hopper burn) during the hard dough stage; however, no significant effects on grain yield was observed; in the wet season, losses were incurred due to lodging of the rice crop during the flowering and ripening stages brought by heavy rains;
- Mean dry season grain yields of the test rice varieties showed significant differences among fertilizer treatments (Table 1); Highest mean grain yield of 7.13 t ha-1 was obtained in the SSNM-N, +PK treatment and was comparable to the +NPK treatment (6.99 t ha-1);
- Lowest mean grain yield of 3.94 t ha-1 was obtained in the zero fertilizer treatment (-NPK);

- Mean grain yields in the minus-one element treatments (+NP, -K; +NK, -P; +PK, -N) were comparable to each other;
- Among the components of yield that contributed to the increase in dry season grain yield was the number of panicles per unit area (Table 2). Highest number of panicles were produced in the +NK, -P treatment at 471.5 m-2 but comparable to the SSNM-N, +PK and +NPK treatments;
- The mean dry season agronomic nitrogen-use efficiencies (AEN) of the rice varieties tested varied with respect to the fertilizer treatments (Figure 1). Highest AEN of 21.1kg grain kg-1 N was obtained in the SSNM-N, +PK treatment. This was followed by the +NPK treatment at 14.5kg grain kg-1 N. Lowest AEN was obtained in the +NK, –P and +NP, –K treatments;
- The indigenous N, P and K supplies of the experimental area during the 2016 dry season cropping is shown in Table 3. Highest N supply of 77.3kg ha-1 was obtained in the –N, +PK treatment. Lower indigenous nutrient supplies were obtained in the unfertilized plots. Indigenous P supplies ranged from 10.2 to 13.0kg ha-1, while 59.1 to 67.0kg ha-1 for K;
- Soil samples were collected for chemical analysi.s

Table 1. Grain yields of the test rice varieties as affected by the fertilizer treatments. 2016 Dry Season, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

FERTILIZER TREATMENT	PSB Rc52	NSIC Rc158	NSIC Rc160	MEAN
-NPK	3.59 c	3.63 c	4.60 bc	3.94 c
SSNM-N+PK	7.15 a	7.14 a	7.09 a	7.13 a
+NK, -P	4.92 b	4.31 bc	4.17 c	4.47 bc
+NP,-K	4.91 b	4.94 b	5.10 b	4.98 b
+NPK	6.96 a	6.97 a	7.03 a	6.99 a
-N, +PK	5.21 b	5.11 b	5.12 b	5.15 b

In a column, means followed by a common letter are not significantly different at the 5% level by Tukey's Honest Significant Difference (HSD) test.

Table 2. The components of yield (average of 3 rice varieties) as affected by the fertilizer treatments. 2016 Dry Season, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

FERTILIZER TREATMENT	YIELD COMPONENTS			
	Spikelets/panicle	Panicle/m^2	Filled Grains, %	1000-Grain wt., g
-NPK	68.1 b	288.2 c	83.5 a	23.9 a
SSNM-N+PK	93.7 a	421.6 ab	78.1 ab	23.5 ab
+NK, -P	83.7 a	471.5 a	53.7 d	21.5 b
+NP,-K	87.4 a	355.6 bc	70.2 c	23.0 ab
+NPK	83.4 a	460.3 a	78.2 ab	23.6 ab
-N, +PK	84.3 a	348.1 c	75.6 bc	23.4 ab

In a column, means followed by a common letter are not significantly different at the 5% level by Tukey's Honest Significant Difference (HSD) test.

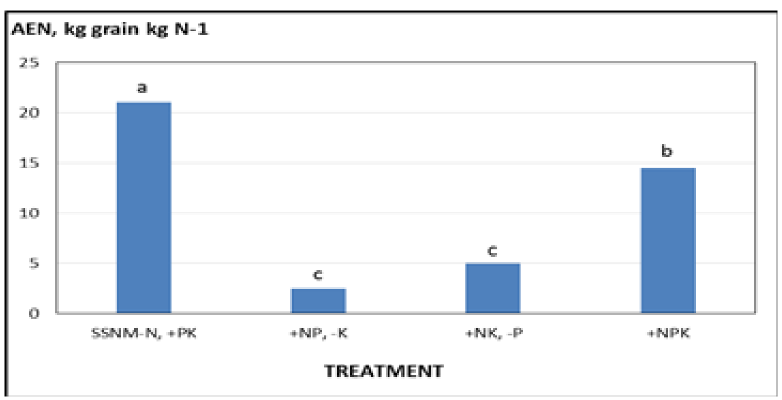

Figure 1. Mean agronomic efficiency of applied N (average of 3 rice varieties) during the 2016 dry season rice cropping. PhilRice CES, Maligaya, Science City of Muñoz, Nueva Ecija.

Table 3. The indigenous nitrogen, phosphorus and potassium supplies of the experimental site during the 2016 Dry Season cropping. PhilRice CES, Maligaya, Science City of Muñoz, Nueva Ecija.

TREATMENT	Indigenous Nutrient Supply, kg ha^{-1}		
	Nitrogen	Phosphorus	Potassium
-NPK	59.1	10.2	59.1
+NK, -P		13.0	
+NP, -K			67.0
+PK, -N	77.3		

Long-term use of organic fertilizers in paddy soils
EFJavier and AEEspiritu

To measure sustainability of soil health/productivity, and grain productivity by an organic-based nutrient management in paddy soils, a factorial experiment on the continuous use of organic fertilizers in paddy soils was started in 2003 wet season at the PhilRice Central Experiment Station. The treatments are: (1) organic fertilizers alone (OF); (2) combined organic and recommended full rate of inorganic fertilizers (OFFR) and; (3) combined organic and half the recommended rate of inorganic fertilizers (OFHR). Control plot (without any amendment) and plots applied with only inorganic fertilizer were also included as check plots. Organic fertilizers include undecomposed rice straw (RS) incorporated 30 days before transplanting (DBT), rice straw with Effective Microorganism Base Inoculants (RSEM) incorporated 14 DBT, chicken manure (CM), and vermicompost (Vc) applied 7 DBT; Azolla microphylla (Am) incorporated 2 DBT. Recommended full rate for inorganic fertilizer was 120-40-60kg NPK ha-1 for DS and 90-40-40kg NPK ha-1 for WS.

Activities:

- Determination of the dynamics of soil organic matter, soil pH and nutrients (macro and micronutrients) in the soils continuously applied with organic material with high and with low C content. Changes in the physical property of the rice soils continuously applied with organic and inorganic fertilizer is also determined.

- Establishment of field experiments to determine the seasonal yield trends of rice plants applied continuously with just organic supplements, and organic fertilizers in combination of inorganic fertilizers. Agronomic N use efficiency was also monitored per season and per year.

- Assessment of grain quality, nutrient content and seed viability of organically nourished rice plants as compared to inorganically fertilized rice plants.

- Establish technical and scientific database for the development of an organic-based rice production management protocol.

Results:

- In 2016DS, there were no significant differences on the yield obtained from the different organic fertilizer tested. The grain yield of the unfertilized plots was comparable with yields obtained from OF (Figure 2).

- Average grain yields in 2016DS showed that pure organic supplements can only yield an average of 5.16t ha-1, while the combination of NPK and organic fertilizers can yield to an average of 6.53t ha-1 similar to applied inorganic NPK fertilizer alone.

- In the 2016WS, there was no significant difference on the yield obtained from the different fertilizer applied. Average yield obtained from OF plots was 5.28t ha-1, while the combination of inorganic and organic fertilizer was 5.09t ha-1 (Figure 2). Lowest yields were obtained from control plot (4.92t ha-1) (Figure 2) which were also obtained in the wet seasons of 2005, 2007, 2010, 2013, and now 2016 (Figure 4).

- Agronomic use efficiency was generally higher in DS than in WS in all treatments (Figure 3).

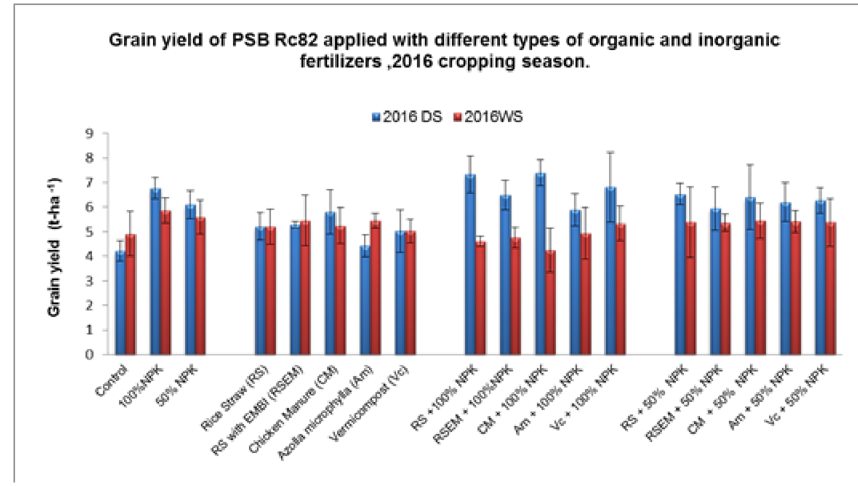

Figure 2. Average seasonal grain yield (tons/ha) of PSB Rc82 applied with different types of organic with and without inorganic fertilizers in 2016 cropping season. PhilRice Central Experimental Station. Science City of Muñoz, Nueva Ecija.

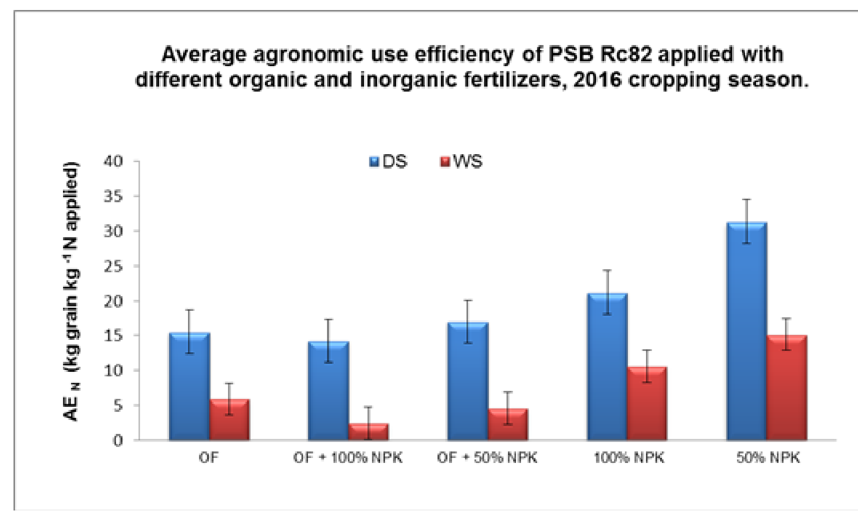

Figure 3. Seasonal agronomic N use efficiency (kg grain kg-1 N applied) of PSB Rc82 applied with different types of organic and inorganic fertilizers in 2016 cropping season. PhilRice Central Experimental Station. Science City of Muñoz, Nueva Ecija.

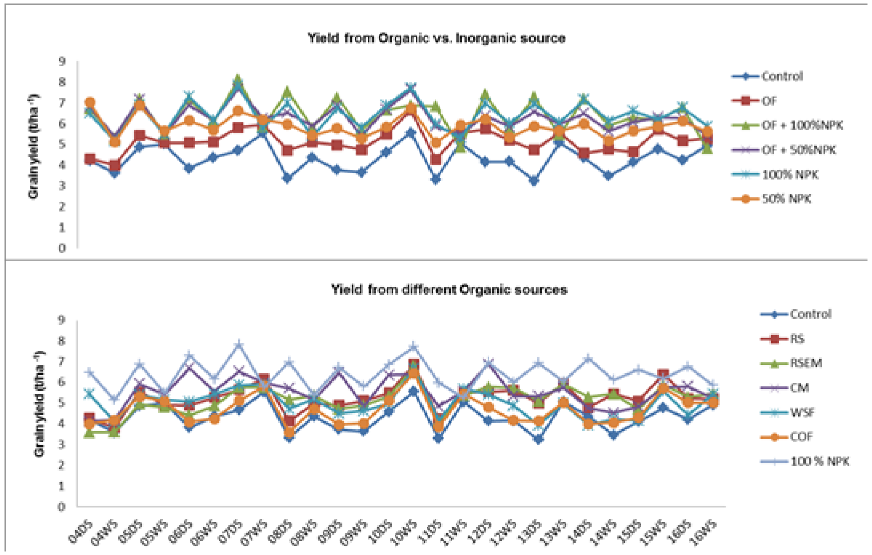

Figure 4. Yield trends of PSB Rc82 applied with different types of organic and inorganic fertilizers across seasons. 2004 to 2016. PhilRice CES, Maligaya clay soil series. Science City of Munoz, Nueva Ecija.

Durability of rice-rice cropping in irrigated lowland ecosystem
JC Magahud, SLP Dalumpines, and WB Collado

A durable production system is achieved if the quality or efficiency of resources used is maintained over time, so that for a given cropping system outputs do not decrease when inputs are not increased. Cropping system durability can be measured by assessing properties contributing to crop productivity that are inherent to the soil, and those contributed by farm practices. By assessing such properties, weaknesses of cropping systems can be identified, so that practices that can make them durable can be employed.

The objectives of the study are to determine the inherent productivity of paddy soils, assess the effect of farmers' nutrient management practices vis-à-vis Rice Crop Manager on soil productivity, and come up with management recommendations for improving productivity of paddy soils.

Suitability analyses based on the method of Sys et al. (1993), nutrient omission techniques, and partial NPK budget analysis of farmers' practice vs. Rice Crop Manager are being conducted in 12 sites: Sta. Cruz, Laguna representing Lipa soil series; Muñoz, Nueva Ecija representing Maligaya series; and San Manuel, Pangasinan representing San Manuel series.

Activities:

- Partial nutrient budget analyses through farmers' interview, field collections of crop and irrigation water samples, and laboratory analyses.
- Suitability analyses through field collections and laboratory analyses of soil samples.
- Yield comparison of farmer's practice vs. Rice Crop Manager (RCM) through field implementation of RCM protocol, and gathering of crop cut data.
- Determining partial nutrient supplying capacities through field collection and laboratory analyses of crop samples.

Results:

- A positive nitrogen (N) balance was observed in most sites except for Sta. Cruz C and San Manuel D (Table 4). In Laguna, high N inputs come from farmers' application of chemical or organic fertilizers. Azolla also grow naturally in these areas. In Nueva Ecija, farmers apply considerable amounts of N fertilizers, and incorporate rice straw. Water irrigated into the farms can also contribute 11 to 23kg ha-1 of N. In Pangasinan, huge quantities of N fertilizers are being applied.
- A negative phosphorus (P) balance was seen in Laguna sites because the amounts removed by the rice crop exceed those added by fertilizers and irrigation water. Meanwhile, P balance was positive in most Nueva Ecija and Pangasinan sites. In Nueva Ecija, farmers apply high amounts of P fertilizers, and incorporate rice straw. In Pangasinan, farmers apply considerable amounts of P fertilizers.
- Potassium (K) balance was negative in all sites because the quantities removed by the rice crop uptake exceed those added as fertilizers or irrigation water.
- Seventy-five percent (75%) of the sites are more acidic than the optimum pH level (Table 5). All Nueva Ecija sites are more acidic than the optimum pH level.
- Sixty-seven percent (67%) of the sites have adequate to high levels of organic matter. All Laguna sites have adequate levels of organic matter.
- Eighty-three percent (83%) of the sites have total N levels

below the optimum. All Nueva Ecija and Pangasinan sites have total N levels below the optimum.

- Ninety-two percent (92%) of the sites have exchangeable K levels below the optimum. All Nueva Ecija and Pangasinan sites have exchangeable K levels below the optimum.

- Coarse fragments and soil depth are optimum or highly suitable for all sites

Table 4. Partial nutrient budget of study sites for 2015 wet season.*

Site	Nitrogen			Phosphorus			Potassium		
	Input (+)	Output (-)	Balance	Input (+)	Output (-)	Balance	Input (+)	Output (-)	Balance
Laguna									
Sta. Cruz A	183	150	+33	12	40	-29	62	254	-193
Sta. Cruz B	187	135	+52	6	44	-38	79	236	-158
Sta. Cruz C	133	229	-96	14	57	-43	63	455	-392
Sta. Cruz D	166	120	+46	15	46	-32	67	275	-209
Average	**167**	**159**	**+36**	**12**	**47**	**-38**	**68**	**305**	**-241**
Nueva Ecija									
Muñoz A	131	129	+6	17	11	+6	57	132	-75
Muñoz B	134	127	+7	17	13	+4	39	123	-85
Muñoz C	137	123	+6	27	14	+13	49	159	-111
Muñoz D	150	111	+39	15	13	+2	38	174	-136
Average	**138**	**123**	**+15**	**19**	**13**	**+8**	**46**	**147**	**-107**
Pangasinan									
San Manuel B	198	116	+82	16	5	+11	41	98	-63
San Manuel C	118	109	+9	5	11	-6	28	200	-172
San Manuel D	110	139	-30	11	10	+1	42	230	-188
Average	**142**	**121**	**+40**	**11**	**9**	**+8**	**37**	**176**	**-128**

*inputs considered are chemical and organic fertilizers applied, irrigation water, and rice straw management; output considered are grain and straw uptake, and rice straw management.

Table 5. Suitabilities of soil properties to rice production (2016 DS for chemical properties).

Site	pH	organic matter %	total N %	exchangeable K me/100 g	Coarse fragments vol %	Soil depth cm
Optimum level	5.6-6.7[a]	>2.67[b]	>0.20[c]	>0.45[d]	>3[a]	>75[a]
Laguna						
Sta. Cruz A	4.8	4.51	0.20	0.15	<3%	>117
Sta. Cruz B	5.5	5.13	0.23	0.17	<3%	>115
Sta. Cruz C	5.8	3.69	0.23	0.47	<3%	>85
Sta. Cruz D	5.6	3.91	0.19	0.34	<3%	>80
Nueva Ecija						
Muñoz A	5.5	3.09	0.13	0.16	<3%	>80
Muñoz B	4.9	2.36	0.10	0.20	<3%	>92
Muñoz C	4.7	3.51	0.14	0.25	<3%	>80
Muñoz D	4.7	2.58	0.10	0.13	<3%	210
Pangasinan						
San Manuel A	4.9	2.39	0.09	0.13	<3%	185
San Manuel B	5.5	3.01	0.11	0.30	<3%	141
San Manuel C	5.3	2.27	0.08	0.21	<3%	115
San Manuel D	5.6	3.03	0.13	0.29	<3%	157

[a]Costelo et al. (2008), [b]Sys et al. (1993),
[c]Descalsota et al. (2005); [d]Dobermann & Fairhurst (2000)

- In 2016 DS, all sites are deficient in N, and 75% are deficient in K and S (Table 6). All Laguna and Nueva Ecija sites are deficient in K, and all Nueva Ecija sites are deficient in S. Seventy-five (75%) of the sites are sufficient in Cu and Zn. All Pangasinan sites are sufficient in Cu, and all Nueva Ecija sites are sufficient in Zn. All Laguna sites are sufficient in P.

- In 2016 WS, all sites are deficient in N and K (Table 7). Eighty-three percent (83%) of the sites are sufficient in Cu, and 92% are sufficient in Zn. All Pangasinan sites are sufficient in S, Cu and Zn. All Laguna sites are sufficient in P.

- For 2016 dry season, grain yields of RCM plots were significantly higher for Sta. Cruz A (5.2 vs. 3.4t ha-1) and San Manuel C (10.1 vs. 6.5 t ha-1), and straw yields of RCM plots was significantly higher for Sta. Cruz B (Table 8a). Straw yields were numerically higher in RCM compared to farmer's practice plots in 10 of the 12 sites studied, including all Laguna sites.

- For 2016 wet season (Table 8b), grain yield of RCM plots was significantly higher for Muñoz D (5.8 vs. 4.9 t ha-1).

- Phosphorus supply was significantly higher in Laguna and Nueva Ecija sites at 8.8 and 8.6kg ha-1, and potassium supply was significantly higher in Laguna sites at 165kg ha-1 (Table 9).

Table 6. Nutrient deficiency (D) and sufficiency (S) in study sites using minus-one element technique for 2016 DS*

Site	Omission Pots					
	-Nitrogen	-Phosphorus	-Potassium	-Sulfur	-Copper	-Zinc
Laguna						
Sta. Cruz A	D	S	D	S	S	D
Sta. Cruz B	D	S	D	D	D	D
Sta. Cruz C	D	S	D	D	D	S
Sta. Cruz D	D	S	D	D	S	S
Nueva Ecija						
Muñoz A	D	S	D	D	S	S
Muñoz B	D	D	D	D	S	S
Muñoz C	D	S	D	D	D	S
Muñoz D	D	S	D	S	S	S
Pangasinan						
San Manuel A	D	D	D	D	S	D
San Manuel B	D	D	S	D	S	S
San Manuel C	D	D	S	D	S	S
San Manuel D	D	D	S	S	S	S

*deficient if rice biomass is <80%, and sufficient if >80% of the biomass planted in the pot supplied with complete set of nutrients.

Table 7. Nutrient deficiency (D) and sufficiency (S) in study sites using minus-one element technique for 2016 WS*

Site	Omission Pots					
	-Nitrogen	-Phosphorus	-Potassium	-Sulfur	-Copper	-Zinc
Laguna						
Sta. Cruz A	D	S	D	S	S	S
Sta. Cruz B	D	S	D	D	D	S
Sta. Cruz C	D	S	D	D	S	S
Sta. Cruz D	D	S	D	D	S	S
Nueva Ecija						
Muñoz A	D	S	D	S	S	S
Muñoz B	D	S	D	S	D	S
Muñoz C	D	S	D	S	S	S
Muñoz D	D	D	D	D	S	D
Pangasinan						
San Manuel A	D	S	D	S	S	S
San Manuel B	D	S	D	S	S	S
San Manuel C	D	S	D	S	S	S
San Manuel D	D	D	D	S	S	S

*deficient if rice biomass is <80%, and sufficient if >80% of the biomass planted in the pot supplied with complete set of nutrients.

Table 8a. Yield comparison for Farmer's Practice vs. Rice Crop Manager plots for 2016 dry season.

Site	Grain yield (t/ha) †		Straw yield (t/ha) ††	
	Farmer's practice	Rice Crop Manager	Farmer's practice	Rice Crop Manager
Laguna				
Sta. Cruz A	3.4 b	5.2 a	5.1 a	6.6 a
Sta. Cruz B	5.8 a	6.1 a	4.6 b	6.5 a
Sta. Cruz C	9.3 a	9.0 a	8.2 a	9.0 a
Sta. Cruz D	9.2 a	9.2 a	6.2 a	7.3 a
Nueva Ecija				
Muñoz A	7.8 a	7.5 a	6.3 a	8.4 a
Muñoz B	5.9 a	5.5 a	7.3 a	8.8 a
Muñoz C	6.7 a	7.3 a	7.1 a	8.7 a
Muñoz D	7.7 a	6.7 a	6.9 a	6.1 a
Pangasinan				
San Manuel A	6.6 a	7.6 a	6.0 a	4.7 a
San Manuel B	5.7 a	5.6 a	6.8 a	7.9 a
San Manuel C	6.5 b	10.1 a	8.9 a	9.4 a
San Manuel D	6.7 a	8.4 a	6.3 a	7.4 a

14% moisture content*, oven-dry basis**
Means (Tukey's test) followed by the same letter for FP vs. RCM are not different at 5% level of significance.

Table 8b. Yield comparison for Farmer's Practice vs. Rice Crop Manager plots for 2016 wet season.

Site	Grain yield (t/ha) †		Straw yield (t/ha) ††	
	Farmer's practice	Rice Crop Manager	Farmer's practice	Rice Crop Manager
Laguna				
Sta. Cruz B	8.1 a	7.7 a	9.4 a	8.7 a
Sta. Cruz C	8.9 a	8.4 a	9.1 a	8.8 a
Sta. Cruz D	8.9 a	6.0 b	8.2 a	9.1 a
Nueva Ecija				
Muñoz A	5.8 a	5.5 a	7.2 a	8.1 a
Muñoz B	5.2 a	4.9 a	7.2 a	6.1 a
Muñoz C	4.6 a	3.8 a	6.9 a	6.5 a
Muñoz D	4.9 b	5.8 a		

14% moisture content*, oven-dry basis**
Means (Tukey's test) followed by the same letter for FP vs. RCM are not different at 5% level of significance.

Table 9. Partial* inherent nutrient supplying capacities of study sites for 2015 WS

Site	Nutrient Indigenous Supply, kg/ha		
	Nitrogen	Phosphorus	Potassium
Laguna	45.5 a	8.8 a	165.6 a
Nueva Ecija	41.7 a	8.6 a	112.8 b
Pangasinan	29.9 a	5.0 b	123.8 b

*from rice straw only; Median (Kruskal Wallis and Mann-Whitney U tests) followed by the same letter for Laguna vs. Nueva Ecija vs. Pangasinan are not different at 5% level of significance.

Improving Agricultural Productivity using Soil-Based Agro-Technology Transfer (SBATT)

SD Cañete, WB Collado, and MV Sanchez

Data on crop performance and yield on different soils are now available but results of researches conducted on certain soils focused only on the crop by climate interaction. This poses a serious limitation on the effective matching of soil properties to anticipated crop yields. Thus, we need to compile data on soil-climate-crop yield relations in order to define the real interactions of these production parameters.

In the Philippines, classification of the soils followed the Soil Taxonomy Framework started in 1984. However, problems in soil characterization aroused and these include, first, the accurate classification, and, subsequently the development of a mechanism for the vertical transfer of classification-derived technology.

Soils need to be classified correctly for effective management of crops and for transfer of technology from one region to the other where similar soils occur. Soil taxonomy has proven its role in this aspect due to its emphasis on quantitative limits for taxa. Soils are grouped according to order, suborder, great group, subgroup, family, and series levels. The sixth category (soil series) was designed base on the similarities in properties such as soil chemical and physical properties; and pedogenesis. Hence, perform similar land use that will eventually provide us the benchmark for the transfer of knowledge or experience from one soil to the other.

The general objective of the study is to test the results of the interpretation of soils based on the soil series level classification using the Soil Taxonomy Framework for agro-technology transfer.

Activities:

- Establish on-farm field trials to validate the rice and non-rice crop performance associated with the requirements to enhance production and;

- Evaluation of the performance of pre-determined suitable rice-based cropping system in selected soil series in terms of seasonal yields, nutrient use efficiency, and profitability.

Results:

- The technology demonstration cum research trial was established in Brgy. San Joaquin, Balungao, Pangasinan (15°56.244’N 120°42.225’E) on January 2016. The area was identified as San Manuel series which is very suitable to various types of crop.

- Suitability analysis disclosed that the existing yellow corn-rice-rice cropping system in the area is highly suitable and was considered in the study. Crop management interventions based on the soil limitations was employed and continuous research on other limitations will be observed and corrected as the study progresses.

- Using the Corn and Rice Crop Manager, the study was able to save on fertilizer usage compared to the farmers practice. For corn, a fertilizer rate of 185-35-65 NPK ha-1 was used in the study while in the farmers plots, 236-77-66 NPK ha-1 was applied. Likewise, rates of 127-35-43 NPK ha-1 and 140-60-60 NPK ha-1 was applied in the study and farmers practice, respectively.

- With majority of farm operations and inputs held similar, except for fertilizer use and management, the study was able to save PhP3,698.93 in corn production and P1,316 in rice production per hectare on fertilizer cost.

- Higher average grain yields were obtained from the study sites over the farmers’ practice across sites and seasons. It generated an average yield advantage of 0.74t ha-1 for corn (Figure 5) and 0.18t ha-1 for rice (Figure 6).

- For corn, yield components disclosed that, the study produced almost the same ear length, ear diameter, and grain weight, but the number of kernels per ear produced across sites are greater than the farmers practice (Table not shown).

- For rice, higher number of panicles per hill, more filled and less unfilled grains per panicle, and heavier grains were produced in the study sites compared to the farmers practice except for site 1 that has lesser filled grains as affected early scheduled harvest due to anticipated upcoming typhoon (Table not shown).

- Higher partial factor productivity (PFPN) from applied nitrogen (N) were observed in the study sites compared to the farmers practice across season with a mean difference of 13.14 and 5.65 for corn and rice, respectively. This translates to higher grain yield as a function of higher N efficiency (Table 10).

- Based on the baseline yield of 6t ha-1 and 5.5t ha-1 for corn and rice, respectively. The study showed an average increase of 2.96t ha-1 on corn and 0.44t ha-1 on rice.

- On the average, Return on Investment (ROI) disclosed more profit generated from the study compared to the farmers practice. An advantage of 28% and 14.07% in corn and rice production, respectively, was attained over the farmers practice.

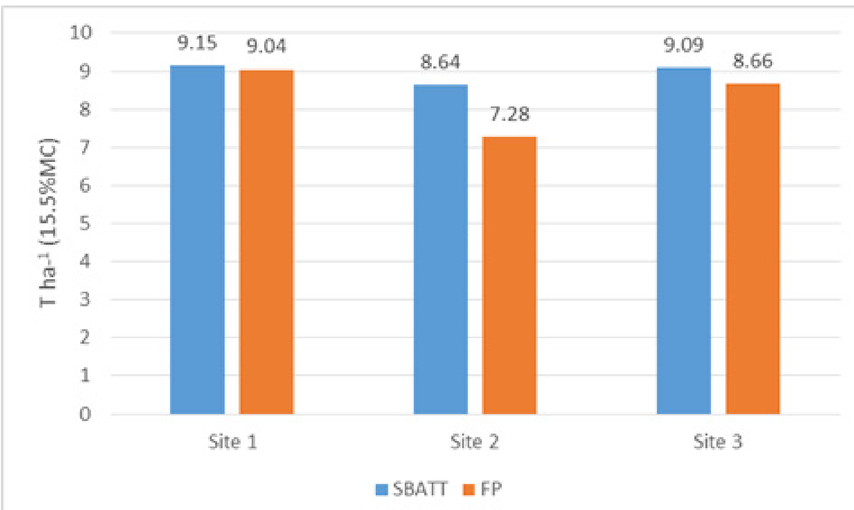

Figure 5. Grain yield of Yellow Corn under San Manuel Series in Balungao, Pangasinan (2016 DS).

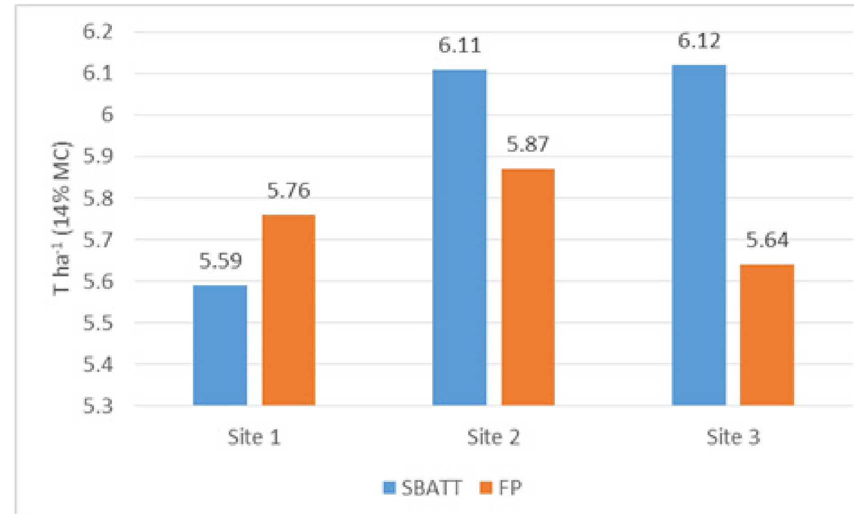

Figure 6. Grain yield of Rice under San Manuel Series in Balungao, Pangasinan (2016 WS).

Table 10. Partial Factor Productivity (PFPN) of applied N (SBATT vs Farmer's Practice).

Site	Corn		Rice	
	SBATT	FP	SBATT	FP
1	49.46	38.30	44.02	41.14
2	46.70	30.85	48.11	41.93
3	49.14	36.69	48.19	40.29
Average	48.43	35.28	46.77	41.12
Mean Difference	13.14		5.65	

II. Development of Soil, Water, Nutrient, and Crop Yield Diagnostic Techniques for Irrigated Lowland Rice

Project Leader: Jasper G. Tallada

Use of diagnostic tools under a specific system of techniques will undoubtedly improve the productivity of rice areas with a corresponding reduction of expenses especially on fertilizers. If the right amounts of fertilizer can be ascertained well in advance at a good level of precision, this could potentially guide the farmers on their application rates and timing. Consequently, this will increase the agronomic use efficiencies of fertilizers and more specifically the nutrient use efficiency. This approach has been shown quite useful particularly for precision agriculture in countries like Australia and the US. This project is aimed at developing a range of tools and techniques that would aid in the recommendation forming process for nutrient management. Crop modelling systems such as the DSSAT crop model has been shown useful for near real-time prediction of future yields once the crop genetic coefficients are determined. A multi-location trial for areas having particular environment stress factors was conducted to better fine tune the technology. Electronic hand-held chlorophyll meters such as the SPAD 502+ had been useful for real-time diagnostics, which can provide good basis for appropriate fertilization rates. One important shortcoming of the technology is the high acquisition costs of the meter. An alternate atLeaf+ has also been shown effective in measuring the status of the plants just like the SPAD meter, but it is many times more cost effective and has greater chance of acceptance. This study is already in its final stage of development. A similar meter called the Pocket Sensor, which is now commercially marketed as the Trimble GreenSeeker works on the NDVI (normalized difference vegetation index) has also the potential for use in rice fields. It makes measurements at the canopy level, unlike the SPAD and atLeaf that works on individual leaves, may be used with nitrogen-rich reference plots for mid-season fertilizer recommendation. An algorithm from NDVI-yield relations is being explored to guide the fertilizer application rates especially during the panicle initiation stage of the rice plant. Another approach exploits the versatility of the camera function of the Android smartphones. It works on hand-captured images of the rice canopy and recommends optimum fertilization rates. Calibration of the average RGB values of images at various capture resolutions with the experimental leaf-tissue analysis is on-going.

The Use of Decision Support System for Agrotechnology Transfer (DSSAT) CERES-Rice Crop Model to Evaluate the Potential Yield of Irrigated Lowland Rice Under Different Nutrient Management Levels and Climate Types in the Philippines

LE Espiritu, SA Balidiong, GU Abordo-Nemeño, ZLE Espina, NS Sosa, GA Castañeda, and RT Cruz

The Decision Support System for Agrotechnology Transfer (DSSAT) is an application software developed to integrate the effects of crop genotype, soil, weather, and management options. In calibrating the model, a set of genetic coefficients of the rice varieties is obtained. Crop genetic coefficients are values that describe the phenology and growth stages of each rice variety grown under optimum crop management. In validating the model, the crop genetic coefficients obtained from calibration will be used to simulate the potential yield of the rice varieties and compare the simulated yield with the observed yield. After calibrating and validating the DSSAT CERES-Rice Crop Model, it can be used to simulate the potential yield of rice under optimum crop management in different locations with varying weather conditions. The DSSAT CERES-Rice Crop Model was utilized in this study to establish a new protocol to determine the yield potential of different inbred and hybrid rice varieties. Hence, nitrogen management levels were tested in relation to attainment of yield potential of rice varieties under irrigated lowland rice areas in PhilRice Nueva Ecija.

Activities:

- Field experiments were conducted at PhilRice Nueva Ecija in 2016 dry season to assess the grain yield potential of three varieties namely, PSB Rc82 (110 days to crop maturity), NSIC Rc160 (122 days) and Mestiso 20 (111 days). For 2016 wet season the varieties were PSB Rc82, NSIC Rc160, and NSIC Rc222 (114 days).

- Fertilizer treatments for dry season were: (1) -N, +P, +K or N omission plot where each P and K was applied at 40 kg ha-1 (2) LCC-based N application wherein 6 bags of Complete fertilizer (CF) 14-14-14-12S was applied at 14 days after transplanting (DAT) before LCC-based nitrogen (N) application. For LCC-based N application, 35kg N ha-1 were applied when LCC reading was below 4. LCC reading was done every week starting at 21 DAT until early flowering, and (3) Growth stage-based N application wherein 50kg N ha-1 was applied at mid-tillering, 100kg N ha-1 at early panicle initiation, and 40kg N ha-1 at early flowering. Fertilizer treatment for wet season were: (1) -N, +P, +K or N omission plot where each P and K was applied at 40kg ha-1 (2) LCC-based N application wherein 4 bags of Complete fertilizer (CF) 14-14-14-12S was applied at 14 days after transplanting (DAT) before LCC-based nitrogen (N) application. For LCC-based N application, 23kg N ha-1 were applied when LCC reading was below 4. LCC reading was done every week starting at 21 DAT until early flowering, and (3) Growth stage-based N application wherein 25kg N ha-1 was applied at mid-tillering, 50kg N ha-1 at early panicle initiation, and 20kg N ha-1 at early flowering.

- Grain yield sample from each treatment was obtained from a representative 5m[2] area, oven-dried and adjusted to standard 14% grain moisture content.

Results:

- In 2016 dry season, LCC-based N application for a total of 112kg N ha-1, PSB Rc82 had a yield of 5.8t ha-1 which is highest among the treatments (Table 11). The yield obtained in N-omission plot with P and K fertilizers is the same with the yield obtained with growth stage-based N application. NSIC Rc160 with LCC-based N application for a total of 112 kg N ha-1 had a yield of 5.6t ha-1 which is highest among the treatments. Increasing the amount of N did not increase the yield. In the N-omission plot with P and K fertilizers, NSIC Rc160 had a yield of 4.7t ha-1 it has the same yield with the treatment Growth stage-based N application with a total of 190kg N ha-1. Mestiso 20, in N-omission plot with P and K fertilizers had a yield of 5.0t ha-1 which is highest among the treatment. Application of N did not increase the yield. The lowest yield was obtained in the Growth stage-based N application with 190kg N ha-1, Mestiso 20 had a yield of 4.5t ha-1.

- In 2016 wet season, Growth stage-based N application with 95kg N ha-1, PSB Rc82 had a yield of 6.1t ha-1 which is highest among the treatments (Table 12). With LCC-based N application for a total of 74kg N ha-1, PSB Rc82 had a yield of 5.8 t ha-1. In the N-omission plot with P and K fertilizers, PSB Rc82 had a yield of 5.4t ha-1 which is lowest among the treatments. Application of N increased the yield of PS Rc82. For NSIC Rc160, Growth stage-based N application with 95 kg N ha-1 had a yield of 6.2t ha-1 which is highest among the treatments. With LCC-based N application, NSIC Rc160 had a yield of 5.9t ha-1 and the N-omission plot with P and K fertilizers had the lowest yield at 5.6t ha-1. Application of N increased the yield of NSIC Rc160. NSIC Rc222 had the highest yield in the treatment LCC-based N application for a total of 74kg N ha-1 at 6.6t ha-1. The lowest yield was obtained in N-omission plot with P and K fertilizers.

- Dry season yields did not achieve the yield targets due to stem borer damage. Wet season yields exceeded the yield targets.

Table 11. Average grain yields of PSB Rc82, NSIC Rc160, and Mestiso 20 in the Control without NPK fertilizers, N-omission plot with P and K fertilizers, LCC-based N application with a total of 112kg N ha-1, LCC-based N application with a total of 147kg N ha-1, Growth stage-based N application with totals of 140 and 190kg N ha-1 in 2016 dry season.

Treatment	Average Yield (t/ha)		
	PSB Rc82	NSIC Rc160	NSIC Rc222
N-omission plot or –N, +P, + K	5.4	5.6	5.0
LCC-based N application with a total of 74 kg N/ha.	5.8	5.9	6.6
Growth stage-based N application with a total of 95 kg N/ha.	6.1	6.2	6.4

Table 12. Average grain yields of PSB Rc82, NSIC Rc160, and NSIC Rc222 in the Control without NPK fertilizers, N-omission plot with P and K fertilizers, LCC-based N application with a total of 112kg N ha-1, LCC-based N application with a total of 147kg N ha-1, Growth stage-based N application with totals of 140 and 190kg N ha-1 in 2016 dry season.

Treatment	Average Yield (t/ha)		
	PSB Rc82	NSIC Rc160	Mestiso 20
N-omission plot or –N, +P, + K	5.3	4.7	5.0
LCC-based N application with a total of 147 kg N/ha.	5.6	5.2	4.7
Growth stage-based N application with a total of 190 kg N/ha.	5.3	4.7	4.5

Evaluation of crop nutrient diagnostic tools techniques for increased nutrient-use efficiency for irrigated lowland rice

JG Tallada and MA Ramos

The SPAD-502+ and atLEAF+ are chlorophyll meters used to assess the leaf nitrogen (N) status in the field prior to N fertilizer application. The SPAD-502+ is commonly used in field experiments at PhilRice but costs Php 100,000.00 per unit. Another chlorophyll meter, the atLEAF+, works on the same principle but less costly at Php15,000.00 per unit. However, before considering cost, there is a need to compare the measurements made by the SPAD-502+ and atLEAF+ and their impact on grain yield and agronomic N use efficiency (ANUE). The study aims to: (1) Determine the SPAD-502+, atLEAF+ chlorophyll meter readings and the level of N fertilizer application for inbred rice in the irrigated lowland field, (2) Compare the level of N fertilizer application , grain yield , ANUE based SPAD-502+, atLEAF+ chlorophyll meter, Leaf color chart readings and the "Fixed-Time" or growth stage-based N fertilizer typically used by farmers.

Table 13. Amount of N applied depending on SPAD and atLEAF values at critical growth stages.

Growth stage	Transplanted rice			
	DAT	SPAD value	atLEAF value	N (kg/ha)
Early tillering	14-20	>36	>46	0
		34-36	44-46	20
		<34	<44	30
Active tillering	20-35	>36	>46	30
		34-36	44-46	40
		<34	<44	50
Panicle initiation	40-50	>36	>46	40
		34-36	44-46	50
		<34	<44	60
Heading to flowering	55-65	>36	>46	0
		34-36	44-46	15
		<34	<44	20

Table 14. Treatments used in the field experiment, PhilRice Nueva Ecija. DS2016.

Treatment	N applied kg/ha				Total N (kg/ha)
	14 DAT	21 DAT	30 DAT	42 DAT	
Zero N	0	0	0	0	0
Fixed-Time	40	0	40	40	120
LCC-based	35	35	35	35	140
SPAD-502+	30	30	30	50	140
atLEAF+	30	30	30	50	140

DAT – Days after transplanting

Table 15. Treatment used in Wet season 2016 field experiment, PhilRice Nueva Ecija.

Treatment	N applied kg/ha							Total N (kg/ha)
	10 DAT	14 DAT	21 DAT	28 DAT	30 DAT	35 DAT	45 DAT	
Zero N	0	0	0	0	0	0	0	0
Fixed-Time	30	0	0	0	30	0	30	90
LCC-based	0	23	23	23	0	0	0	69
SPAD-502+	0	20	30	30	0	30	0	110
atLEAF+	0	20	30	30	0	30	0	110

Activities:

- Field experiment was established at PhilRice-CES during the dry season and wet season of 2016. Geographically, the station is located at 15°40'25.6°N, 120°53'45.75°E and 56 meters above sea level. The soil of the experimental field is Maligaya Series.

- After removing some crop residues, the land was plowed, harrowed twice and leveled for rice transplanting. 21-day old seedlings were transplanted at 20 by 20cm spacing. Recommended amounts of phosphorus (60kg P2O5) as solophos (phosphorus 18 %) and potassium (60kg K2O) as muriate of potash (potassium 60 %) where applied as top dress 10-14 DAT. During the cropping season, along with rainfall, irrigation was provided using canal water and water pump water. Plots were kept flooded and drained at least 10 days before harvesting. Handweeding was done, and pest control followed standard practices.

- Crops were harvested by hand using sickle at maturity located at the center of each plot for a total of 125 hills. Grains were separated in straw manually, dried and weighed.

- Chlorophyll readings were taken weekly with a Minolta SPAD-502+ and atLEAF+, starting 14 DAT. Ten hills were chosen at random in each plot. From each plot, the uppermost fully expanded leaf was used to read three readings in the bottom, middle and top portion of the leaf blade avoiding the midrib and then take the mean per reading. The data collection started in early stage until initial flowering growth stage.

- Significant treatment mean differences were determined using Tukey's at 5% level of significance by SPSS software.

Results:

- The critical value of SPAD in the Philippines is 35 in dry season but there was no established critical value for atLEAF. Using the atLEAF converter into SPAD unit, 45 atLeaf reading is equivalent to 35 SPAD units.

- As expected, the control treatment remained having the least reading in both chlorophyll meters throughout the growing period.

- Chlorophyll meter readings increased as fertilizer rates increased from 0 to 140kg N ha-1 see Figure 7A and 7B.

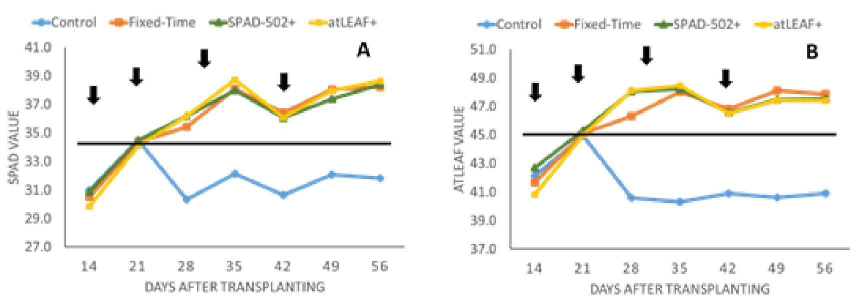

Figure 7A is the SPAD reading and **Figure 7B** is the atLEAF reading of inbred PSB Rc82 at different growth stages (i.e., 14 to 56 days after transplanting).

Table 16. Grain yield and agronomic nitrogen use efficiency (ANUE) of PSB Rc82 in response to different N treatment during Dry Season 2016.

Treatment	Total N applied (kg ha-1)	Grain Yield (kg ha-1)	ANUE
Zero N	0	5603.8c	-
Fix-Time	120	7164.5a	13.0
LCC-based	140	6884.4a	9.4
SPAD-based	140	6424.2b	5.8
atLEAF-based	140	6235.2b	4.5

- Fix-time fertilizer application has the highest grain yield and agronomic N use efficiency (ANUE) and with a lesser N fertilizer applied compared to the treatment that is based on CM which has a lower grain yield and ANUE (Table 16).

- The atLEAF readings were higher than the SPAD readings but

the manner of recommendation approach was essentially the same.

- The atLEAF and SPAD can be used in monitoring the chlorophyll status of rice plant but the amount of N to be applied needs verification and adjustment that should increase the grain yield and ANUE. The SPAD recommendation of 35 or 45 for atLeaf has to be re-investigated.

- AtLeaf can be as good as SPAD for NDVI measurements. Based on R2 , at early tillering was low at 0.0006 because the leaves were still quite narrow at this stage, active tillering was 0.7779 because of high variability in the range of measurements due to significant variability from the observed segregation of values, panicle initiation was high at 0.9970, booting stage was also high at 0.9218. This implies that at PI stage atLEAF has as good prediction estimation as SPAD (Figure 8) which describes crop-stage suitability in the use of chlorophyll meters. The atLEAF can perform substantially well compared to SPAD for leaf chlorophyll measurement of rice at lesser investment cost.

- Cost savings of atLEAF over SPAD is 85 %, while the atLEAF and SPAD have similar user performance during field use.

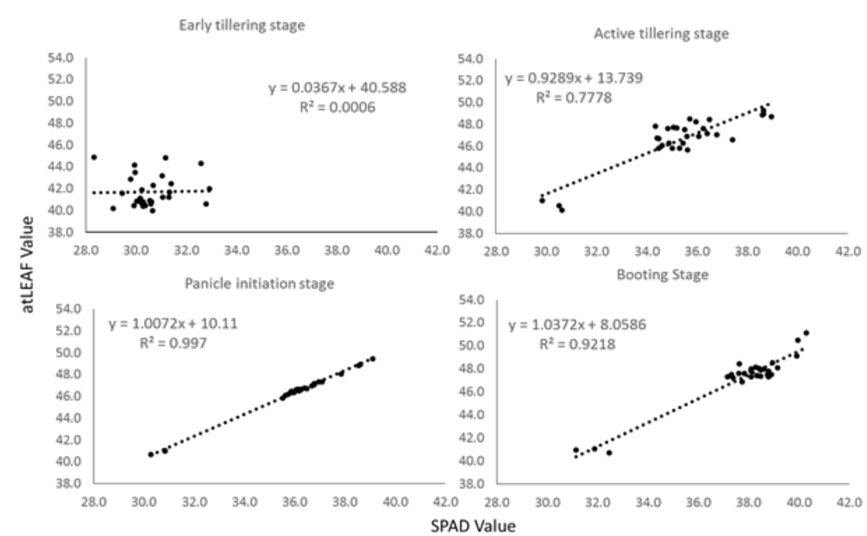

Figure 8. Correlation of SPAD and atLEAF in different growth stages of rice during Dry season 2016.

Recommendation:

- The atLEAF chlorophyll meter can now be used by extension workers or progressive farmers to help them in monitoring the rice field where the use of SPAD is plausible, and the atLEAF unit would equally help them make a decision on the right amount and time of N fertilizer application.

- It would be extremely useful if a similar technology can be locally developed that woult further reduce the cost of the meters.

Estimating Mid-Season Nitrogen Requirements of Rice Based on Nitrogen-Rich Strip
JG Tallada and MA Ramos

The yields of most cereal crops vary from season to season even in plots receiving the same levels of fertilizer. Climatic elements particularly solar radiation and temperature may explain a significant portion of the variation, but there are edaphic and cultural factors such as nutrient mineralization rates and water availability during the fallow period that may further add explanation on yield variance over time. Nitrogen-rich plots are reference plot where the crop receives adequate balanced nutrition to maximize its yield.

Nitrogen is one of the most limiting nutrient in Philippine soil and the farmers practice apply high amounts of nitrogen in order to produce high yield but the yield is changing every year. N-rich plots will be a guide to the farmer for a proper time of applying nitrogen during midseason by visual assessment of the n-rich plot crop and crop in the other representative plots. By doing this it can help the farmers in decision making for a timing of nitrogen application and improve nutrient use efficiency.

In this study the Oklahoma State University (OSU) prototype pocket sensor was used. The normalized difference vegetative index (NDVI) reading from the pocket sensor is practically the same as the NDVI from a more robust GreenSeeker handheld crop sensor.

The study aims to develop algorithms for fertilizer recommendations based on the N-rich plots as a reference guide in applying nitrogen fertilizer at mid-season growth stage of rice plant. To establish a nitrogen requirement and yield prediction model using NDVI measurements obtained from the prototype pocket sensor.

Activities:

- The study was conducted at PhilRice CES in 2016 dry and wet season. Experiments were laid out in randomized complete block design with inbred rice cultivar PSB Rc82 in three replicates. There are six fertilizer N (as urea) management treatments described in Tables 17 and 18. The plot size was 9.5m by 6m (57m^2). 21-day old seedlings were transplanted in a 20 cm by 20 cm planting distance with 2 to 3 seedlings per hill. Cultural management for weeds and pest management was done when necessary. Recommended amounts of phosphorus (60kg P2O5) as solophos (phosphorus 18 %) and potassium (60kg K2O) as muriate of potash (potassium 60 %) where applied as top dress during 14 DAT, amounts of nitrogen as urea (46kg N) were applied in three splits in different N level as treatments.

Table 17. Treatment structure and description of the trials conducted at PhilRice CES, DS 2016.

Treatment	Early tillering (14 DAT)	Tillering (30 DAT)	Panicle initiation (45 DAT)	Total N applied (kg/ha)
T1	0	0	0	0
T2	N-Rich Plot			340
T3	40	40	40	120
T4	30	30	Sensor-based	120.2
T5	45	45	Sensor-based	134.9
T6	60	60	Sensor-based	140.2

Table 18. Treatment structure and description of the trials conducted at PhilRice CES, WS 2016.

Treatment	Early tillering (14 DAT)	Tillering (30 DAT)	Panicle initiation (45 DAT)	Total N applied (kg/ha)
T1	0	0	0	0
T2	N-Rich Plot			340
T3	30	30	30	90
T4	30	30	Sensor-based	152
T5	45	45	Sensor-based	169
T6	60	60	Sensor-based	184

Sensor readings were taken weekly with a prototype GreenSeeker sensor starting at early tillering to initial flowering stage. The sensor is 50cm above the plant canopy and measured in one square meter.

Equations used in computing the N rate requirement at midseason based on N-Rich Plot were:

YP_NRS is the target yield (12,000 kg/ha)

$$RI = \frac{NDVI_{NRS}}{NDVI_{FF}}$$

$$YP_0 = \frac{YP_{NRS}}{RI^{0.67}}$$

$$\Delta Y = YP_{NRS} - YP_0$$ ---i.e. additional grain yield

$$N\ rate\ requirement\ at\ PI = \frac{\Delta Y \text{ x \% N in grains}}{\text{NUE}}$$--- ---i.e. additional N in grains

Where: YP – Yield potential, NRS – Nitrogen Rich Strip, RI – Response Index, NDVI – Normalized difference vegetation index, YP0 – Previous yield, NUE - Nitrogen use efficiency, FF – farmers field or representative plots

Assumptions:
12,000 kg ha^{-1} – Maximum yield of PSB Rc82
0.67 – Coefficient of rice grain yield and NDVI at PI
0.0106 – Grain N uptake percent

Results:

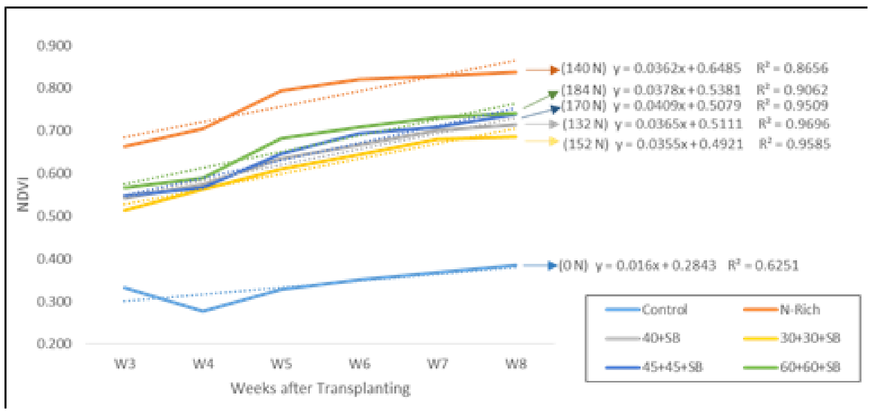

Figure 9. Changes in NDVI from early tillering to panicle initiation stage of rice with varying amounts of N.

- NDVI differed significantly with different N rates and growth stages indicating that it can be used to determine the time of N application considering the proper N application and right timing of sensor reading (Figure 9).

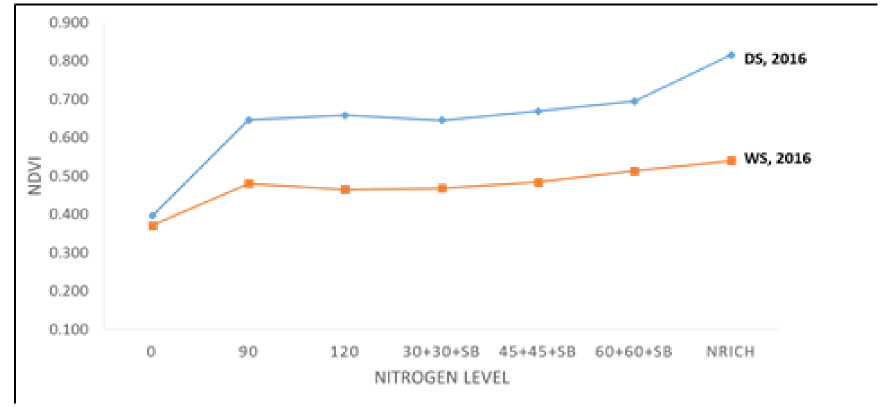

Figure 10. NDVI as influence by different N level at panicle initiation stage during dry season and wet season 2016, PhilRice Maligaya.

- NDVI differed significantly in cropping season and different N treatment (T1 = Zero N applied, T2 = 90kg N-1, T3 = 120kg N-1, T4 = 30kg N + 30kg N + Sensor-based N applied, T5 = 45kg N + 45kg N + Sensor-based N applied, T6 = 60kg N + 60kg N + Sensor-based N applied and T7 = N-Rich reference plot) indicating that in can be used to estimate N fertilizer requirement of rice (Figure 10).

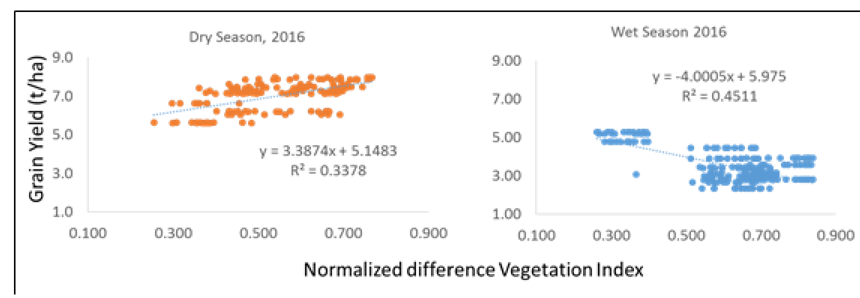

Figure 11. Relationship between NDVI and grain yield of rice during dry and wet season 2016, PhilRice Maligaya.

- NDVI in DS 2016 has positive relationship to the grain yield meaning as NDVI increases the grain yield also increases while on the wet season NDVI has negative relationship to the grain yield due lodging of the crop during reproductive stage that resulted to low yield (Figure 11).

Recommendation:

- Further experiment will be conducted to develop the algorithm for N fertilizer recommendation in rice. The coefficient of the yield-NDVI model needs to be re-assessed seeking to outperform the yields realized in the farmers' practice.

Development of an Android Application version of the Leaf Color Chart (LCC) for a more precise Nitrogen topdress application in rice
AOV Capistrano, JJE Aungon and JEG Hernandez

Nitrogen is a macro-element essential to rice for the promotion of growth and other yield parameters measured through the number of chlorophyll and its concentration or the leaf N content. There are different devices and methods to identify leaf-N concentration like the Minolta SPAD 502 and other chlorophyll meters yet too expensive for an ordinary farmer. The cheapest alternative among them is the cost effective and equally functional Leaf Color Chart developed by PhilRice. Following the LCC procedures requires visual skills to assess and generate accurate recommendation. Although cheap and practical, adoption and popularity of this tool is very low to the majority of rice farmers. This study aims to develop an android application version of the Leaf Color Chart (LCC) for precise N-topdress application in rice and increase its appeal by incorporating a "high-tech" essence to the LCC technology using smartphone cameras.

Activities:

- Field Experiment: Conducted three MOET setup (for each variety) to identify basis for fertilizer recommendation. Established 27 unique treatments of different % N levels applied at basal, tillering and panicle initiation to the three irrigated lowland rice varieties (PSB Rc82, NSIC Rc226 and NSIC Rc238); a total of 81 plots established.

- Leaf Sampling: Captured leaf color image of 10 leaf samples per plot per stage before N fertilizer application using 6 rear cameras of 6 different brands of android smartphones with varying pixel sizes (5MP, 8MP, 13MP).

- Gathered and processed 10 same hills per plot for tissue N Analysis for correlation analysis with the images (Figure 14).

- Android application development: On-going development of the mobile application to turn an android-based smartphone into a functional chlorophyll meter/leaf/ N assessing device and N fertilizer advisor.

Results:

- Initial data on the grain yield as of Dry season showed the Nitrogen Use Efficiency at different N levels applied in NSIC Rc226 (Figure 12) . Red bars indicated that for every ton of grain yield there is 20 to 30kg N applied. Furthermore Figure 13 showed that NSIC Rc226 needed 135kg ha-1 N to get the 6t ha-1 yield and 159kg ha-1 N for 7t ha-1 yield respectively, the least amount among the three varieties.

- Further correlation analysis will be done in the grain yield and leaf image as soon as the data of the tissue N analysis becomes available.

- 60% progress on the development of the LCC android application (Figure 15 and 16):
  - Developed process for extracting Red, Green and Blue (RGB) values from the leaf image.
  - Developed RGB to Hue, Saturation and Brightness (HSB) values conversion.
  - HSB will be converted to Dark Green Color Index (DGCI) which will be correlated to the Nitrogen leaf concentration.

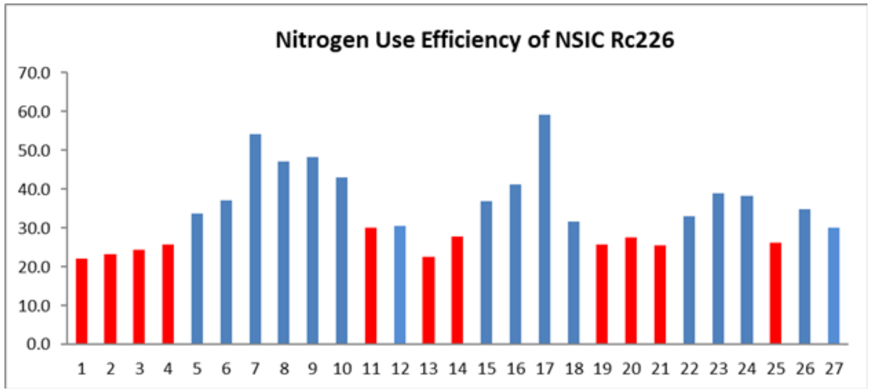

Figure 12. Nitrogen use efficiency at different N levels of NSIC Rc226.

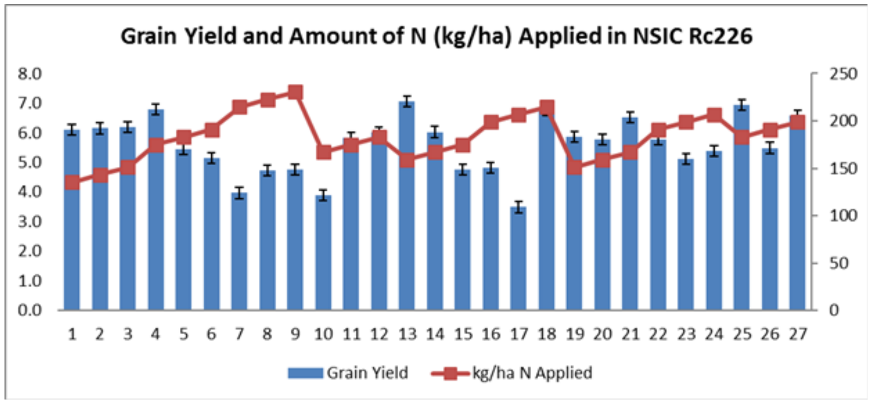

Figure 13. Grain yield and amount of N (kg ha-1) applied in NSIC Rc226.

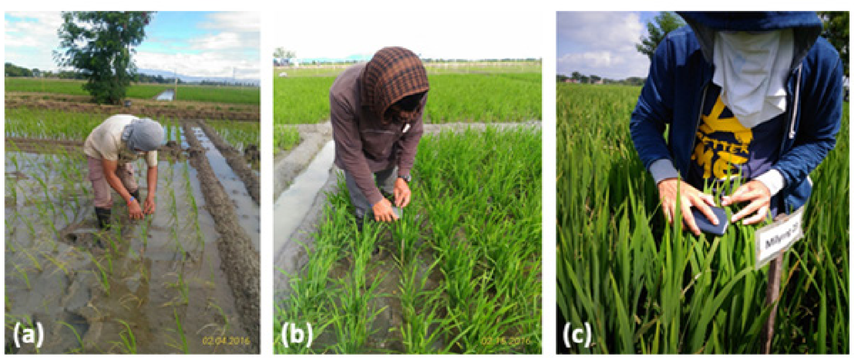

Figure 14. Leaf image capture: (a) before the 1st fertilizer application; (b) during tillering stage; (c) during panicle initiation.

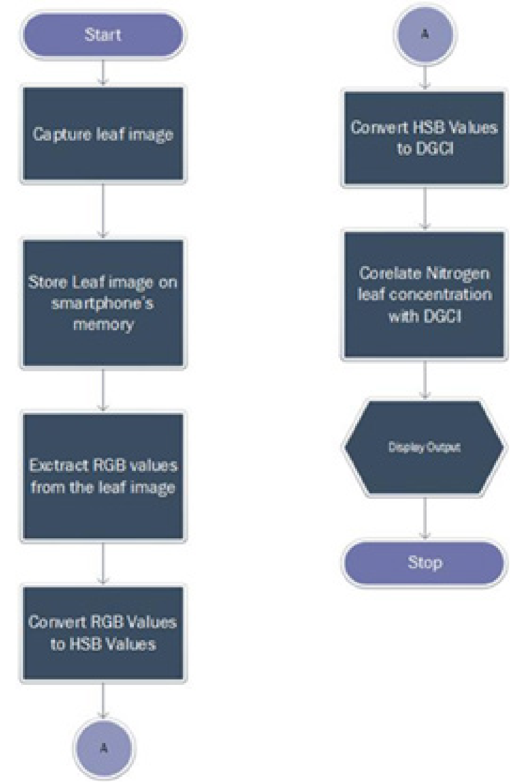

Figure 15. LCC App development flow chart.

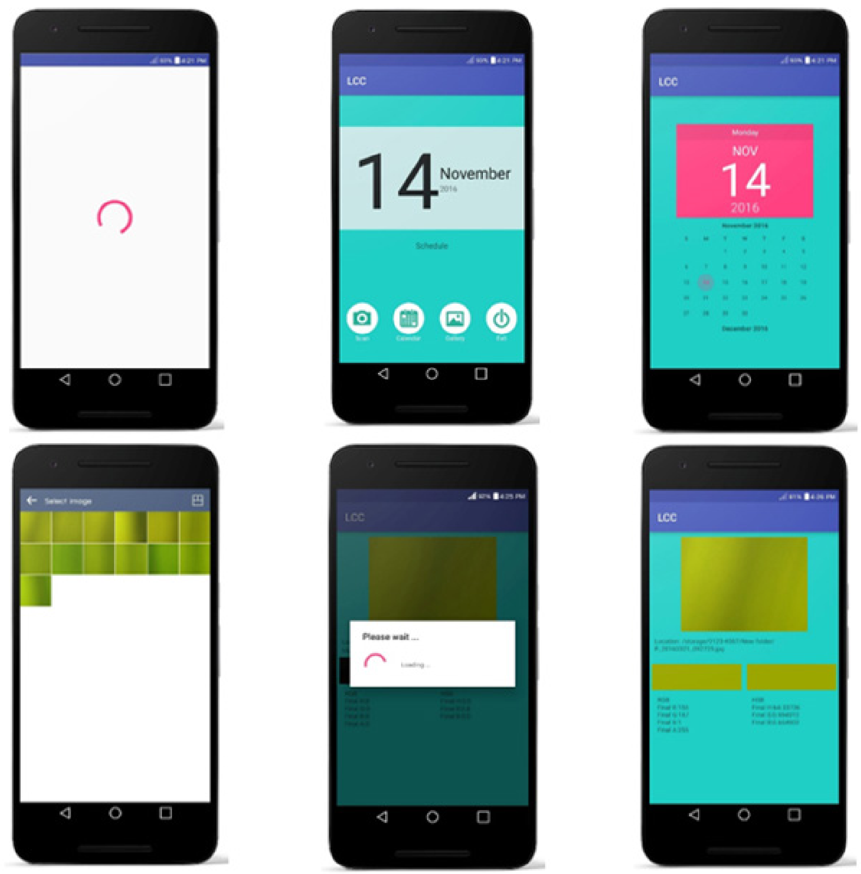

Figure 16. Alpha Version of LCC Android Application.

III. Assessment and Evaluation of Crop Intensification and Resource Use Efficiency in Rice Production

Project Leader: Myrna D. Malabayabas

The project aimed to continuously develop and improve rice production technologies that will contribute in the efficient utilization of crop inputs such as water and nutrients to increase yield and possibly reduce input costs. Thus, the project evaluates rice varieties or genotypes with improved crop management techologies that can increase at least 15% yield. The adoption of resource-use efficient intergrated crop management technologies like controlled irrigation, Leaf Color Chart (LCC), fixed rate and time of nutrient application, and tillage technqiues would enhance the efficiency of inputs.

Evaluation of water and nitrogen use efficiencies of high yielding varieties under conventional and minimum tillage

MD Malabayabas, AJ Espiritu and NR Dadufalza II

Nutrients and water are vital factors in the attainment of higher rice productivity. However, the cost of fertilizer is continuously increasing while water is becoming scarce. Water and nutrients must be efficiently utilized by rice to compensate for the high production cost. The adoption of resource use efficient technologies like controlled irrigation, Leaf Color Chart (LCC) and minimum tillage in combination with high yielding varieties should be considered to reduce production cost while maintaining productivity.

Activities:

- Conventional and minimum tillage were employed during land preparation. Minimum tillage involved dryland rotavation after which the field was kept flooded for 10 days before seeding followed by 1 harrowing and land leveling. Conventional tillage involved wetland plowing, 3 harrowing and land leveling.

- Pre-germinated seeds of PSB Rc18, NSIC Rc160, Rc222, Rc238, Rc240 and Rc298 were broadcast-seeded at the rate of 20kg ha-1.

- Three bags of complete fertilizer (14-14-14-12S) were applied 14 days after seeding and N was topdressed at the rate of 35 kg ha-1 when LCC reading fell below 3. N omission plots were also installed in each treatment plot.

- The field was irrigated at 10 DAS with standing water maintained at 2 to 5cm depth until 21 days after seeding (DAS). Thereafter, irrigation schedule was based on the perched water table in the observation well (15 cm below the soil surface).

- Water productivity (WP) and agronomic efficiency for nitrogen (AEN) and grain yield were determined.

Results:

- WP ranged from 0.59 to 1.13kg grain cm^{-3} water (Figure 17). WP among varieties and between tillage methods did not differ significantly. However, there was significant interaction between varieties and tillage. In conventional tillage, NSIC Rc160 had significantly higher WP than Rc238 while the rest had comparable WP. NSIC Rc160 and Rc238 had higher WP with conventional tillage.

- AEN of the 6 varieties tested ranged from 18.77 to 26.7 kg grain kg N-1 (Figure 18). AEN among varieties and between tillage methods did not significantly differ. The total N rate used in all varieties with LCC-based application including the N from 3 bags of complete fertilizer applied at 14 DAS was 126kg N ha-1.

- Grain yield ranged from 6.43 to 7.27t ha-1 in conventional tillage and 5.76 to 6.54t ha-1 in minimum tillage (Figure 19). Tillage methods did not significantly affect grain yield.

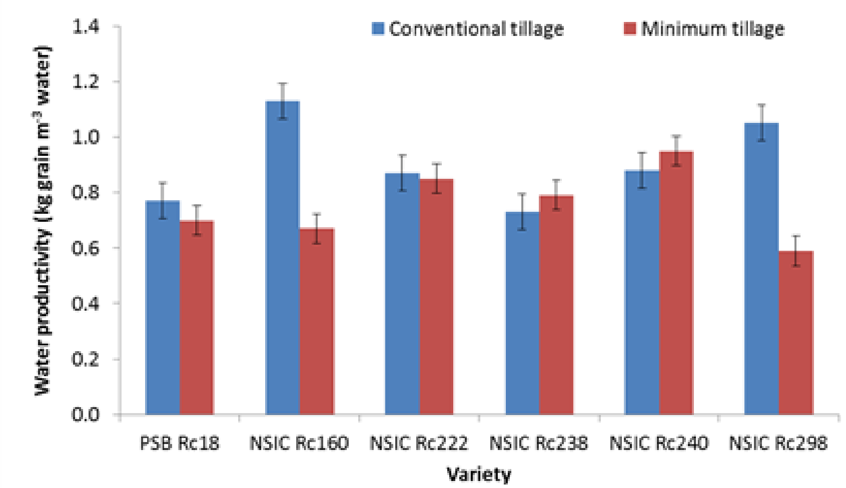

Figure 17. Water productivity (WP) of varieties under conventional and minimum tillage, PhilRice CES, 2016 DS.

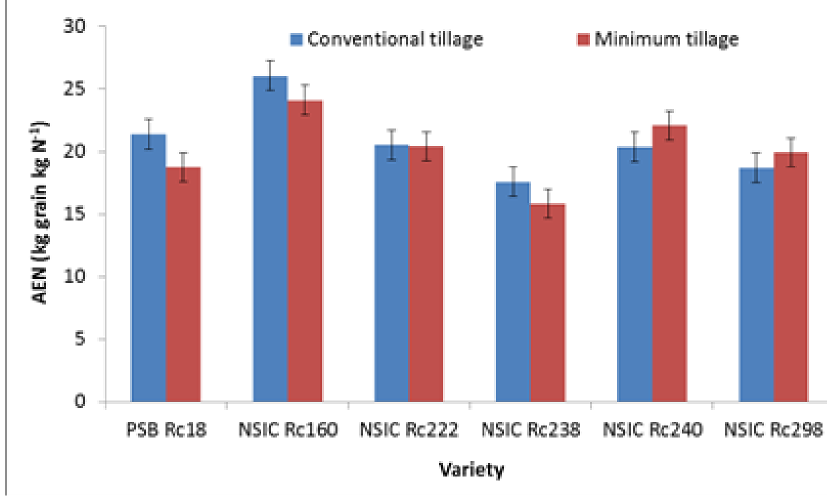

Figure 18. Agronomic efficiency for nitrogen (AEN) of varieties under conventional and minimum tillage, PhilRice CES, 2016 DS.

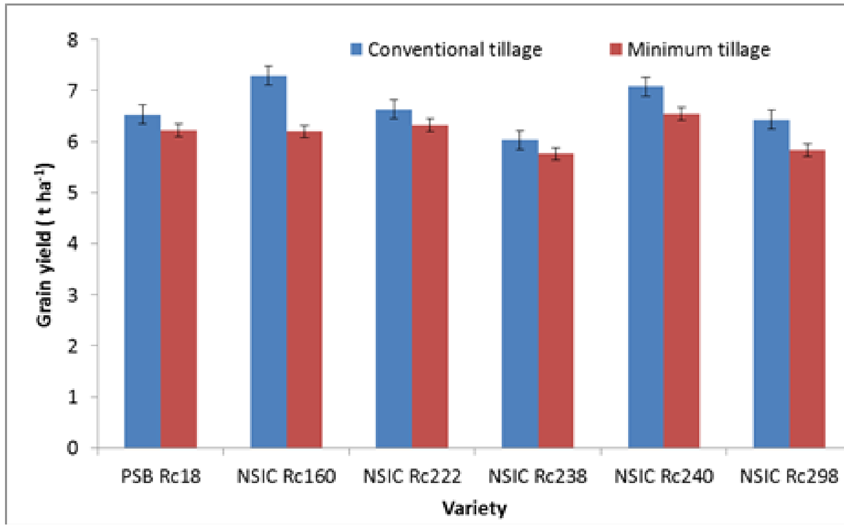

Figure 19. Grain yield of varieties under conventional and minimum tillage, PhilRice CES, 2016 DS.

Investigating the effect on soil physicochemical properties and pests incidence in the three rice-based crop rotations under upland environment.

MJT Mercado; VC Lapitan and LJ Zablan

Rice mono-cropping is one of the most common farming systems in the Philippines. However, continuous rice cultivation leads to low productivity of the land due to depleted soil fertility and deterioration of the soil physical property (Yadav and Chauhan, 1998). Soil deterioration as manifested in lower yield of the crops, poor crop stand and other environmental problem thus, crop diversification plays an important role. The growing demand for sustainable agriculture leads in nutrient recycling through organic sources in restoring soil fertility and sustaining crop productivity (Ghosh, 2013). Crop rotation plays a vital part in good nutrient recycling through organic matter incorporation, efficient water management, and maintaining ecological balance of the area. In crop rotation based system, different management must be implied to attained desirable yield and improving the over-all balance in the system. The study aims to evaluate and document the effect of different crop rotations in the upland environment on some soil physical and chemical and biological attributes.

Activities:

- Determine the effect of the three rice-based cropping patterns on the soil properties under upland condition.
- Assess the ecological diversity in each cropping systems in-terms of insect and weed population.
- Determine the variations of crop productivity under the different rice-based crop rotation systems.

Results:

Soil property assessment:

Soil Fertility (pH, C:N ratio and %OM)

- Initial soil collection was conducted prior to planting in 2016 Wet Season (WS) establishment. Comparing to last 2016 DS analysis, soil pH values remain the same ranging to moderately acidic (pH 6.0 to slightly acidic pH6.1- pH 6.5).
- Two plots planted previously with Mungbean (Vigna radiata L.) in 2016 Dry Season (DS) showed slight increase in the soil Organic Matter % comparing to the last analysis collected prior to establishment in 2015 WS, whereas soil Organic Matter % decrease in plots planted with corn. No significant change in the phosphorus and potassium content in the soil.

Ecological Diversity:

Weed diversity

- A total of twenty-two (22) weeds were identified to be present in the plots established in 2016 Wet Season cropping consisting of fourteen (14) broadleaf weed species, four (4) grass species and four (4) sedge species.
- At vegetative phase, 16 weeds were identified consisting of twelve (12) broadleaf, three (3) grass and one(1) sedge species. Whereas at reproductive phase, twenty (20) weed species consisting of twelve(12) broadleaf, four (4) grass and four (4) sedge species collected.
- During the rice vegetative stage, Cyperus rotundus and Echinochloa colona were the most frequent weed species present (all plots) followed by Celosia argentea, Ipomea triloba and Rottboellia cochinchinensis (8 plots) whereas at the reproductive stage , Echinochloa colona and Ludwigia octovalvis (8 plots) followed by Cyperus rotundus and Fimbristylis littoralis (6 plots).
- Cyperus rotundus (1,030 individuals) is the most dominant while Portulaca oleraceae is the least dominant (1 individual) weed species during the vegetative stage and Fimbristylis littoralis (185 individuals) and least Vernonia cinerea (1 individual) at reproductive stage.
- Highest weed density was found to be Cyperus rotundus (114.44) followed by Celosia argentea (24.44) at vegetative phase while Echinochloa colona (13.78) and Cyperus rotundus (12.78) at reproductive phase.
- Highest abundance during vegetative stage was found to be Cyperus rotundus (114.44) and Cleome rutidosperma (32.6) and at reproductive stage, Cyperus difformis (35.5) and Fimbristylis littoralis (30.83).
- Six (6) new weed species were collected at reproductive phase and two (2) weed species were displaced respectively during the cropping period.
- Using the Shanon Weinner Diversity index, H’ value was higher in reproductive stage H’= 2.43 than in vegetative phase

H′= 1.84. Values state that diversity of weed species was higher at reproductive phase of the cropping period.

- Evenness also follows the same trend, high in reproductive phase 0.81 than vegetative phase 0.66.
- Based on the data collected, weed management must be based on weed density rather than frequency appearance of the weed. Weed control must be based on the highest density value species through herbicide application and manual hand weeding.

Insect Diversity

- Eighteen (18) insect species were collected during the cropping period consisting of nine (9) beneficial and nine (9) harmful insect.
- Highest frequencies were observed insects: Green Leaf hopper (7); Lady beetles both on nymph (7) and adult (7) form followed by brown plant hopper (6) and spiders (6).
- Based on computed density, green leafhopper (15.44) ranks first followed by spiders (9.89).
- Same trend were observed on computed dominance, green leafhopper (19.86) ranks first followed by spiders (14.83).
- Based on visual observation and computed values, ratio for beneficial and harmful insects were equal and will not cause significant damage even if no insect management performed.

Figure 20. Rice-Weed interaction in the 2016WS prior to weed sampling.

IV. Assessment and Evaluation of Variety, Water, Nutrient and Pest Interactions

Project Leader: Leylani M. Juliano

The project aimed to develop a holistic approach in crop and pest management. The interaction of nutrient and water with the prevalence of pests and diseases should be evaluated to come up with a strategy to better manage these complexities in crop management. Variety evaluation along with its response to the application of nutrients, the interaction of water and the prevalence of pests and diseases pose a complex interaction among growth resources of the rice plant. Studies under this project are implemented in the different stations.

The use of rice varieties with high yield potential is one of the key factors in achieving higher productivity. Along with genotype, crop management like nitrogen application and location has large contribution to the attainment of yield potential. Therefore, the maximum yield potential of new varieties and even promising lines and the associated N management at specific location must be determined before recommendation to farmers and other stakeholders. Varieties with high yield potential should reach farmers to contribute to the goal of rice sufficiency. Hence, nutrient management especially on the use of nitrogen (N) is fundamental in achieving the yield potential of any variety.

Effects of water management and fertilizer N levels on rice yield (PSB Rc82) and incidence of pests and diseases in the rainfed rice ecosystem (ASD-006-001)

AY Alibuyog, SV Pojas and LL Soliguen

Large areas for rainfed lowland rice, including areas in the Ilocos Region, have poor soils with a high degree of spatial and temporal variability in water availability. These have direct implications on nutrient management, particularly nitrogen (N). These adverse environmental conditions require adjustment on nutrient management, depending on the progress of the season, to maximize fertilizer-use efficiency. Untimely application of N fertilizer due to unavailability of water results in lower yield; unbalanced application may likewise cause buildup of pests and diseases. Owing to uncontrollable scenarios in rainfed areas, identifying of a window of opportunity when to apply N at its optimum level without compromising yield is necessary. The 3-year study includes 5 fertilizer and 3 water management treatments.

Activities:

- Research data from the 2014 and 2015 wet season (WS).

- The same set of treatments (3 water regime and 6 N treatments) in 2015 wet season were re-evaluated in 2016 WS.

- Establishment of the field setup, crop care and maintenance, data gathering and analysis were conducted in 2016 WS.

Results:

- Water management had no significant effect on the yield of PSB Rc82 for both 2014 and 2015 setups; however, supplemental irrigation (WR3) resulted to less weeds and less infection of brown spots.

- Result in 2014WS shows that among the N levels, the application of 120-30-30kg NPK/ha (N5) gave higher yield (2,728kg/ha) than the application of 90-30-30kg NPK/ha (N3 and N4) though statistically comparable. Among the treatment combinations, WR3N5 had the highest yield (3, 251kg/ha).

- In 2015 WS, N5 gave the highest yield (4,429kg/ha), but it was comparable with N3, N4 and N6. A 9.5% yield decline was observed when 120kg N/ha application was increased to 150 kg N/ha. WR3N4 gave the highest (4,794kg/ha) yield among the treatment combinations.

- Results from the 2016WS setup showed that water and N application had no significant interaction in all the parameters except for the number of tillers at tiilering stage. Likewise, mater management did not significantly affect yield and other parameters except for plant height. On the other hand, N treatments had significantly affected all the parameters measured except for the number of filled grains, harvest index, number of tillers at tillering stage.

- The highest yield was observed from the application of 120 and 150kg N/ha, with a yield of 4072 and 4044 kg/ha, respectively but were comparable (Table 19).

- The application of 150 kg N gave the highest tiller count but still comparable with 120kg N. Likewise, higher N application produced significantly taller plants. Plant height was affected by water regime at tillering and booting stages but not at mature grain stage.

- Other data on yield components and soil nutrient status after the set up are not yet available.

- The initial result of the study was presented through poster during the 46th CSSP Conference in General Santos City on June 13 to 17, 2016 and through oral presentation during the 2016 National Rice R&D Conference on September 7 to 8, 2016. The paper was also selected and presented for paper competition during 2016 Regional R&D Highlights held at the University of the Northern Philippines on November 7-8, 2016 as sponsored by the ILAARRDEC.

Table 19. Yield of PSB Rc82 as affected by water regime and Nitrogen N Levels . PhilRice Batac. WS2016.

N Levels	Water Regime			Mean
	W1	W2	W3	
N1	2375	2704	2393	2491c
N2	2980	3070	2872	2974bc
N3	3505	3347	3272	3374ab
N4	3442	3268	3934	3548ab
N5	4146	4185	3802	4044a
N6	3877	4200	4142	4073a
Mean	3387.67	3462	3403	3417
Significance	Water Regime		ns	7.76
	N Levels		**	12.74
	WR x N Levels		ns	7.39

The influence of timing and level of nitrogen and potassium application on physiological traits responsible for high yield heterosis on hybrid rice and parental lines

ML Pini

Rice is an important agricultural commodity with more than 155 million hectares grown worldwide. It can be grown using a variety of cultural management practices. Tillage systems, seeding rates, and nitrogen (N) rates are management factors that are critically important in achieving optimum rice grain yields. N is one of the essential macro-elements for rice and the most yield-limiting nutrient in rice production because of its vital morpho-physiological functions. N is the main nutrient associated with yield. Its availability promotes crop growth, tillering and number of panicles and spikelet during the early panicle formation stage. Although most our soils were N deficient sources like rainfall, crop residues, manures and commercial inorganic fertilizer can replenish it. The amount of N fertilizer needed to optimize crop yield often differs significantly from one field to another. In other hand, potassium absorbed during the reproductive and ripening phases wherein it increases the plants resistance to diseases affecting the panicle and grains and it also increases the protein content of the grains, thus improving the quality of the crop. At present, different levels of nitrogen and potassium are formulated to address the needs of rice. However, the best level and timing of N and K application must be determined to prevent the early and late flowering of parental lines and hybrid leading to poor synchronization.

Activities:

- Conducted soil sampling at PhilRice Isabela field and pre-analyzed in the analytical services laboratory (ASL) to determine each chemical properties.

- The set-up was laid out in split-plot design with three replications. Mestizo 55 was the variety used, a newly-hybrid variety.

- The treatments were applied in different level and timing. Chemical control for weeds, snails and prevalent insects were applied to minimize the damages caused by these pest.

- There were 11 NPK fertilizer treatments, with five (5) levels of N as follows; 0kg, 100 kg, 120kg, 150kg and 180kg. Both P and K are fixed to 60 kg for the first 5 treatments. There were 4 levels of K as follows; 0kg, 20kg, 60kg and 100kg combined with fixed 100kg and 150kg of N, respectively.

Results:

- Soil chemical properties obtained include soil pH, organic carbon, available P and available K (Table 20).

- In DS 2016, the 180kg N ha-1 and 60kg K ha-1 with three splits applied at 14, 28 and 35 DAT attained the highest yield among treatments (Table 21). Heading of plants were first observed in treatment 1 (0 N and 60kg K ha-1).

- In WS 2016, the 150kg N ha-1 and 100 K kg/ha with three splits at 14, 28 and 35 DAT attained the highest yield (10.73t ha-1) as shown in Table 22. Heading of plants were first observed on the plots with less nitrogen applied.

Table 20. Soil chemical properties at PhilRice Isabela, DS 2016.

	pH	OM content (%)	Available P (ppm)	Available K (ppm)
Soil chemical properties (level)	5.0	2.7	34.5	70

Table 21. Yield and yield components of M55 as affected by different nitrogen and potassium fertilizer level treatments in irrigated lowland ecosystems in PhilRice Isabela, DS 2016.

Treatment	Tiller Count	Biomass(g)	Grain Yield(t/ha)
0-0-60	10.08 b	127.50 b	5.77 c
100-0-60	13.50 ab	148.50 ab	7.08 bc
120-0-60	12.38 ab	146.50 ab	8.10 ab
150-0-60	13.42 ab	181.00 ab	8.59 ab
180-0-60	16.46 a	213.67 a	9.10 a
100-0-0	14.12 ab	162.00 ab	7.04 bc
100-0-20	13.5 ab	165.00 ab	7.49 abc
100-0-100	12.71 ab	152.50 ab	7.67 abc
150-0-0	14.67 ab	172.50 ab	8.62 ab
150-0-20	15.00 ab	183.83 ab	8.39 ab
150-0-100	15.46 a	182.50 ab	8.90 ab

*Means with the same letter are not significantly different at 5%level of significance.

Table 22. Yield of M55 as affected by different nitrogen and potassium fertilizer level treatments in irrigated lowland ecosystems in PhilRice Isabela, WS 2016.

Treatment	Grain Yield(t/ha)
0-0-60	8.11b
100-0-60	9.78ab
120-0-60	9.61ab
150-0-60	10.02ab
180-0-60	8.91ab
100-0-0	8.47b
100-0-20	9.25ab
100-0-100	8.91ab
150-0-0	9.73ab
150-0-20	9.42ab
150-0-100	10.73a

Means with the same letter are not significantly different at 5% level of significance.

Yield Potential of Irrigated Lowland Varieties in Response to Nitrogen Management

MD Malabayabas, RT Cruz and NR Dadulfalza II

Nutrient management particularly nitrogen (N) is crucial in the attainment of higher rice yield potential and increased crop productivity. Thus, a study was conducted at PhilRice CES in 2016 Dry Season (DS) and Wet Season (WS) to determine the yield potential and agronomic efficiency for N (AEN) of early to medium maturing varieties and their response to N management. Treatments were arranged in split plot design with N as main plot and variety as sub-plot in three replications. The N treatments were (N1) Nitrogen omission plot (NOP) or 0 N + 40kg ha-1 P_2O_5, + 40kg ha-1 K20 + 10kg ha-1 $ZnSO_4$ applied 1 day before transplanting (DBT); (N2) PalayCheck recommendation of 6 bags 14-14-14-12S in DS and 4 bags in WS + 10kg ha-1 $ZnSO_4$ applied at 14 days after transplanting (DAT) + N

topdressing of 35kg N ha-1 in DS and 23kg N ha-1 in WS when Leaf Color Chart (LCC) LCC reading fell below 4; (N3) fixed N rate 190kg N ha-1 in DS and 95kg N ha-1 in WS , applied in 3 splits - at mid-tillering, early panicle initiation, and early flowering + 40kg ha-1 each of P_2O_5 and K_2O + 10kg ha-1 $ZnSO_4$ applied at 1 DBT. The test varieties were NSIC Rc122 (121 days), NSIC Rc238 (110 days), NSIC Rc240 (115 days), NSIC Rc302 (115 days), NSIC Rc308 (111 days) and NSIC Rc360 (122 days) with PSB Rc18 (123 days) and Rc82 (110 days) as checks.

Activities:

- Crop establishment: 21 days old seedlings were transplanted on January 12, 2016 for DS cropping and on June 28, 2016 for WS cropping.
- LCC reading in LCC-based N application was done weekly starting at 21 days after sowing until first flowering. In the fixed-rate N application, N fertilizer was applied at midtillering, early panicle initiation and first flowering.
- At panicle initiation stage, 4-hill samples per plot were collected for determination of leaf area index, plant height, tiller number and aboveground biomass.
- At physiological maturity, grain yield was obtained from 5 m2 area adjusted to 14% moisture content. Samples for yield component analysis were taken from 8-hill samples.
- Agronomic efficiency for N (AEN) was determined by subtracting the yield in the unfertilized plot from the yield in the fertilized plot over the total rate of applied N fertilizer.
- Pest incidence or damage was assessed at hard dough stage by the Crop Protection group.

Results:

- In DS, the average grain yields across varieties were 4.92, 7.38 and 7.40t ha-1 with NOP, LCC-based and fixed-rate N applications, respectively. The yields between LCC-based and fixed-rate N management did not differ significantly. Across N management, yields of test varieties ranged from 5.83 to 7.13t ha-1. NSIC Rc238, NSIC Rc240, NSIC Rc302, NSIC Rc308 and NSIC Rc259 had comparable yield with PSB Rc82 (Figure 21). On the other hand, Rc238 and Rc308 had significantly higher yield than PSB Rc18. There was no significant interaction between N management and variety during DS.

- In WS, grain yields ranged from 3.30 to 4.18t ha-1 in NOP, 6.12 to 6.7t ha-1 with LCC-based N method and 6.46 to 7.75t ha-1 with fixed-rate of 95kg N ha-1 (Table 23). Most varieties except NSIC Rc308 had significantly higher yields in the fixed-rate N application of 95kg ha-1 than in the LCC-based N application with rates ranging from 51 to 74kg N ha-1. NSIC Rc240 had significantly the highest yield in all N management treatments (Table 24).

- AEN in DS was significantly higher with PalayCheck LCC-based N application (28.20kg grain kg-1 N) than the fixed-rate N application of 190kg ha-1 (13.03kg grain kg-1 N). The total rate of applied N fertilizer with LCC-based N management including N from the 6 bags complete fertilizers applied at 14 DAT ranged from 77 to112kg N ha-1.

- AEN in WS ranged from 28.5 to 38.1kg grain kg-1 N with fixed-rate N application and 32.27 to 55.0kg grain kg-1 N with LCC-based N method. AEN this 2016 WS was relatively higher than the previous season because grain yields in the NOP were lower than the yields in DS which resulted in higher AEN. Nevertheless, AEN with LCC-based N management was significantly higher than in the fixed-rate N application. NSIC Rc302 in the LCC-based N management showed the highest AEN among varieties but not significantly different from PSB Rc18, NSIC Rc240 and NSIC Rc360.

- There was 25.3 to 35.8% savings on NPK fertilizer cost with PalayCheck LCC-based N application in DS and 2.4 to 12.2% in WS.

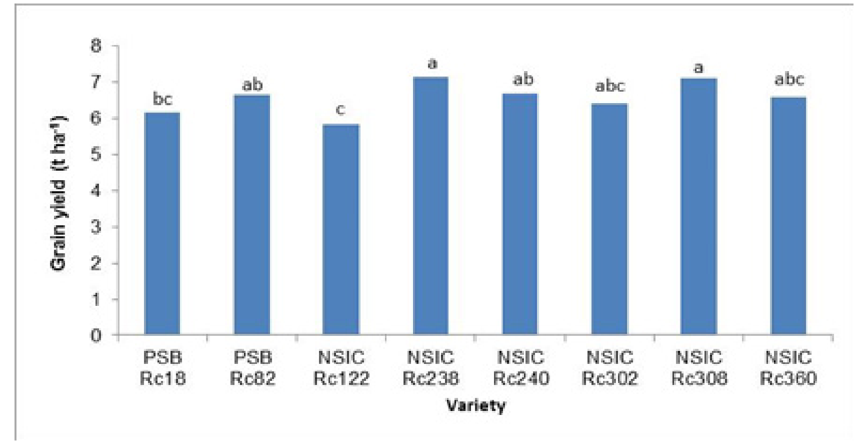

Figure 21. Grain yields of varieties across N management, PhilRice CES, 2016 DS.

Table 23. Comparison of grain yields of each variety with N management showing main effect of N, PhilRice CES 2016 WS.

N management	PSB Rc18	PSB Rc82	NSIC Rc122	NSIC Rc238	NSIC Rc240	NSIC Rc302	NSIC Rc308	NSIC Rc360
NOP	3.43 c	3.76 c	3.30 c	3.47 c	4.18 c	3.39 c	3.82 b	3.76 c
LCC	6.12 b	6.14 b	6.31 b	6.03 b	6.70 b	6.19 b	6.31 a	6.31 b
Fixed N rate	6.46 a	6.67 a	6.65 a	6.65 a	7.75 a	6.55 a	6.52 a	7.37 a

In a column, means with the same letter are not significantly different at 5% level of significance by LSD.

Table 24. Comparison of grain yield of varieties in each N management showing main effect of variety, PhilRice CES 2016 WS.

Variety	N management		
	NOP	LCC-based	Fixed N rate
PSB Rc18	3.43 c	6.12 b	6.46 c
PSB Rc82	3.76 b	6.14 b	6.67 c
NSIC Rc122	3.30 c	6.31 b	6.65 c
NSIC Rc238	3.47 c	6.03 b	6.65 c
NSIC Rc240	4.18 a	6.70 a	7.75 a
NSIC Rc302	3.39 c	6.19 b	6.55 c
NSIC Rc308	3.82 b	6.31 b	6.52 c
NSIC Rc360	3.76 b	6.31 b	7.37 b

In a column, means with the same letter are not significantly different at 5% level of significance by HSD.

Optimizing crop establishment and water management technologies for organic rice production systems of PhilRice Negros
BUT Salazar and CU Seville

PhilRice Negros was designated as the institute's organic rice center in 2011. Since then, the station's research activities were refocused on explaining the science behind organic farming, as well as on the improvement of practices. In 2012, average yield of organic rice in the station is 2.3t ha-1, 1 ton lower compared with conventional rice. Increasing the yield will increase the production, and the income of the station since organic rice are commercially sold at P60kg-1. One way to increase the production is to optimize the practices under organic rice seed production system.

The study aimed to optimize crop management technologies, specifically seedling age and water management, for organic rice seed production system of PhilRice Negros. The factorial experiment (3x2x3) was laid out in split-split plot design, with fertilizer management (conventional, organic, zero) as the main plot, water regime as the sub-plot (controlled irrigation and flooded), and seedling age (10, 15, 20) as the sub-sub-plot. With 18 treatment combinations and 3 replicates per treatment, the experiment was conducted in 54 plots at 25 m^2 per plot.

Results:

- Dry season 2016 set-up was done to verify the result of DS 2015 experiment.

- Result of DS 2016 set-up showed that interaction between fertilizers, water management, and seedling age did not cause significant differences in all parameters (Tables 25 and 26).

- The differences observed in height, tiller number, number of productive tilles, total number of grains, filled grains and yield were mainly due to the different fertilizer treatments. Across fertilizer treatments, plants fertilized with chemical fertilizers had more tillers, and most number of filled grains as well as total number of grains, compared to plants under organic and control (no fertilizer applied) fertilizer management.

- While the main effects of the different water management regimes caused differences in the number of tillers 30 days after transplanting only, seedling age on the other hand caused significant variations in plant height, filled grains and yield. Transplanting older seedlings (15 and 20 days old) yielded more field grains, compared to younger seedlings under the inorganic fertilizer management. However, under organic and zero fertilizer management, seedling age did not cause significant differences in filled grains.

Table 25. ANOVA for main effects and interaction effects of different fertilizer management, water management, and seedling age on the height and tiller count of NSIC Rc222, DS2016.

Treatment	Height (cm)		Tiller count (no)	
	Days after transplanting		Days after transplanting	
	30	60	30	60
Fertilizer (F)	*	*	*	*
Water (W)	ns	ns	*	ns
Seedling Age (SA)	*	*	ns	ns
FxW	ns	ns	ns	ns
FxSA	ns	ns	ns	ns
WxSA	ns	ns	ns	ns
FxWxSA	ns	ns	ns	ns
c.v. (F), %	12.35	4.98	16.2	12.64
c.v. (FxW), %	7.51	5.49	9.7	13.44
c.v. (FxWxSA), %	9.51	5.58	14.9	15.6

[1]A 3x2x3 factorial experiment laid out in split-split plot design, with fertilizer management or F (conventional, organic, zero) as the main plot, water regime or W as the sub-plot (controlled irrigation and flooded), and seedling age or SA (10, 15, 20) as the sub-sub-plot. ns-not significant; *significant at 5% level.

Table 26. ANOVA for main effects and interaction effects of different fertilizer management, water management, and seedling age on the yield and some yield components NSIC, DS2016.

Treatment	Productive Tillers (no)	Filled grains (no)	Total number of grains (no)	Spikelet Fertility (%)	Yield (t ha^{-1})
Fertilizer (F)	*	*	*	ns	*
Water (W)	ns	ns	ns	ns	ns
Seedling Age (SA)	ns	*	ns	ns	*
FxW	ns	ns	ns	ns	ns
FxSA	ns	*	*	ns	ns
WxSA	ns	ns	*	ns	ns
FxWxSA	ns	ns	ns	ns	ns
c.v. (F), %	7.29	7.47	6.03	8.75	17.31
c.v. (FxW), %	18.58	14.18	12.14	10.34	12.81
c.v. (FxWxSA), %	5.53	9.76	10.42	10.66	9.93

[1]A 3x2x3 factorial experiment laid out in split-split plot design, with fertilizer management or F (conventional, organic, zero) as the main plot, water regime or W as the sub-plot (controlled irrigation and flooded), and seedling age or SA (10, 15, 20) as the sub-sub-plot. ns-not significant; *significant at 5% level.

V. Development of Crop Management Practices for Stress Environments

Project Leader: Rolando T. Cruz

Addressing the challenges in the stress environments can be done through the development of technologies that could adapt to the challenges of the changing climate. The development of crop management practices for stress environments with the aim to increase yield by 10 to 15% is the integration of component-technologies of the PalayCheck for drought-prone or submergence-prone areas. There is a need to develop technologies based on the crop management areas of the PalayCheck that could be adapted in these areas such as use of varieties with flood or drought tolerance, water management technologies, among others to provide recommendations appropriate in these areas.

Flood Tolerance of Rice Genotypes In Relation to Crop Management

RT Cruz and LL Espiritu

Rice yield is reduced by abiotic stresses, nutrient deficiencies (Lafitte et al. 2004) and biotic stresses due to pest and disease (Peterson and Higley 2010). Types of abiotic stresses in the rainfed lowland ecosystem are flooding, submergence, drought, and salinity. The said abiotic stresses and high temperature are anticipated to worsen as the consequences of climate change (Mackill et al. 2010). Yields ranged from 1.0 to 2.0t/ha in flood-prone or submergence-prone rainfed lowlands (Bhowmick et al. 2014) and much lower than the average yield of 4.0t/ha in the irrigated lowlands (PhilRice-BAS 2011). The flood-prone ecosystems of South and Southeast Asia are characterized by a wide variety of conditions, particularly timing, duration, intensity of rainfall and floods, soil types, topography, and prevailing biotic and abiotic stresses (Ram et al. 2009). Short-term flooding or short-term partial flooding (STPF) occurs when 30 to 50cm floodwater depths partly submerge the rice plants in the field for 2 weeks. Compared to physiological, molecular and genetic studies on flooding and/or submergence tolerance of rice genotypes (Zhang et al. 2015), relatively few studies were conducted on crop and resource management (Gautam et al. 2014) and their relationship to flood and/or submergence tolerance. Rice crop productivity can be improved and sustained by combining flood tolerance of rice genotypes or varieties with the appropriate crop management. The present study assessed (a) growth and dry matter yield of rice genotypes in response to short-term partial flooding (STPF), *i.e.*, 2 weeks duration of flooding with 30cm and 50cm floodwater depths at vegetative stage in the screenhouse and (b) growth and yield of rice genotypes in response to short-term partial flooding (STPF) with 30 cm and 50 cm floodwater depths, seedling age, and post-flood N applications in the field at PhilRice Nueva Ecija.

Activities:

Screenhouse

The genotypes tested in the screenhouse were PSB Rc82, NSIC Rc194, PSB Rc18, and PR41543-B-14-2-1-2. The susceptible check was IR42 and the tolerant checks were Ciherang Ag+ Sub1 and FR13A. Plants were exposed to short-term partial flooding at 21 to 35 days after transplanting (DAT) in concrete tanks. Plant height, tiller count, shoot elongation rate, and dry matter yield were assessed before, during, and after the flooding treatments.

Field

The genotypes tested in the field were PSB Rc82, PR41543-B-14-2-1-2, and the tolerant check Ciherang Ag+ Sub1. Plants were exposed to short-term partial flooding at 21 to 35 days after transplanting (DAT). Pre-germinated seeds of PSB Rc82, PR41543-B-14-2-1-2, and Ciherang Ag+ Sub1 were grown in seedbed for 21 and days before transplanting in the experimental field. Solophos at 40kg ha-1, Muriate of Potash at 40kg ha-1, and Zinc Sulfate at 10 kg ha-1 were applied one day before transplanting (DBT). Urea fertilizer was applied in two splits: (a) 23kg N ha-1 at mid-tillering or 19 DAT prior to flooding and (b) 47kg N ha-1 was applied at (b1) 2 days after de-flooding and (b2) 7 days after de-flooding. The performance of the rice genotypes was assessed in terms of grain yield.

Results:

Screenhouse

A. 3cm floodwater depth from 21 to 35 days after transplanting

- One day before flooding, plant heights of the 7 rice genotypes ranged from 50.0 to 78.5cm (Table 27). Plant heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 78.5cm and 50.0cm, respectively, and 50.2cm for the susceptible check IR42. One week after flooding (28 DAT), plant heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 88.7cm and 61.3cm, respectively. Plant heights of NSIC Rc194, PSB Rc18, PR41543-B-14-2-1-2, and IR42 ranged from 63.0cm to 64.2cm and were similar to plant height of Ciherang Ag+ Sub1 but significantly lower than plant height of PSB Rc82 and FR13A. Two weeks after flooding (35 DAT), plants heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 116.3cm and 75.0cm, respectively. Plant heights of NSIC Rc194 and PR41543-B-14-2-1-2 ranged from 69.2cm to 71.8cm and were similar to plant height of IR42 but significantly lower than plant height of Ciherang Ag+ Sub1, PSB Rc18, and PSB Rc82 (75.0cm to 89.0cm). FR13A was consistently tallest and reached 116.3cm (Table 27).

- Three weeks after de-flooding (56 DAT), plant heights of the tolerant check FR13A and Ciherang Ag+ Sub1 were 134.0 cm and 88.7 cm, respectively, and 60.7 cm for IR42. Plant heights of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, and PSB Rc82 ranged from 88.9 cm to 108.3 cm and were similar to plant height of Ciherang Ag+ Sub1 but significantly lower than the plant height of FR13A. The tolerant check FR13A was tallest at 134.0 cm.

- One day before flooding, tiller numbers of the 7 rice genotypes ranged from 4 to 6 tillers/plant (Table 27). Tiller numbers were 5 tillers/plant for the tolerant checks FR13A and 4 tillers/plant for the susceptible check IR42. One week after flooding (28 DAT), tiller numbers for the tolerant checks FR13A and Ciherang Ag+ Sub1 were 5 tillers/plant and 6 tiller/plant, respectively. Tiller numbers for NSIC Rc194, PR41543-B-14-2-1-2,PSB Rc18, IR42, FR13A and Ciherang Ag+ Sub1 were similar at 6 tillers/plant. PSB Rc82 had the lowest tiller number of 4 tillers/plant. Two weeks after flooding (35 DAT), tiller numbers for the tolerant checks FR13A and Ciherang Ag+ Sub1 were 6 tillers/plant and 5 tillers/plant, respectively. Tiller numbers for NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, and IR42 ranged from 5 to 6 tillers/plant and were similar to tiller number of the tolerant checks FR13A and Ciherang Ag+ Sub1. PSB Rc82 had the lowest tiller number of 4 tillers/plant.

- Three weeks after de-flooding (56 DAT), tiller numbers for the tolerant checks FR13A and Ciherang Ag+ Sub1 ranged from 3 to 5 tillers/plant and were similar to tiller numbers of NSIC Rc194, PR41543-B-14-2-1-2,PSB Rc18, PSB Rc82, and IR42.

- One week after flooding (28 DAT), shoot elongation rates of the tolerant checks FR13A and Ciherang Ag+Sub1 were 0.28 cm/day and 0.32 cm/day, respectively (Table 28). Shoot elongation rates of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, PSB Rc82 and IR42 ranged from 0.25 to 0.49cm/day. PSB Rc82 had the lowest shoot elongation at 0.25 cm/day. Two weeks after flooding (35 DAT), shoot elongation rates of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 1.08 cm/day and 0.71 cm/day, respesctively. Shoot elongation rates of NSIC Rc194, PSB Rc18, PSB Rc82, PR41543-B-14-2-1-2, and IR42 ranged from 0.57 to 0.99cm/day. The susceptible check IR42 had the lowest shoot elongation rate of 0.57 cm/day.

- Three weeks after de-flooding (56 DAT), shoot elongation rates for the tolerant checks FR13A and Ciherang Ag+ Sub1 were 1.59 cm/day and 1.10 cm/day, respectively. Shoot elongation rates of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, PSB Rc82, and IR42 ranged from 0.30 to 1.54cm/day. The susceptible check IR42 had the lowest shoot elongation rate of 0.30cm/day.

- One day before flooding, aboveground biomass of the 7 rice genotypes ranged from 1.6 to 3.8 g/plant (Table 29). Aboveground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 1.6 g/plant and 1.7 g/plant, respectively. Aboveground biomass of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, PSB Rc82, and IR42 ranged from 1.6 to 3.0 g/plant and were similar to the aboveground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1. Belowground biomass of the 7 rice genotypes ranged from 0.17 to 0.53 g/plant (Table 29). Belowground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 0.17 g/plant and 0.20 g/plant, respectively. Belowground biomass of NSIC Rc194, PSB Rc18, PSB Rc82, PR41543-B-14-2-1-2, and IR42 ranged from 0.20 to 0.53 g/plant and were similar to the belowground biomasses of the tolerant checks.

- Three weeks after de-flooding (56 DAT), aboveground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 23.9 g/plant and 12.2g/plant, respectively. Aboveground biomasses of PSB Rc18, PR41543-B-14-2-1-2, and IR42 ranged from 11.8 to 18.3 g/plant and were similar to the aboveground biomass of Ciherang Ag+ Sub1 but were lower than the aboveground biomass of FR13A. PSB Rc82 had the lowest aboveground biomass at 10.7 g/plant. Belowground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 3.9g/plant and 2.0g/plant, respectively. Belowground biomasses of PSB Rc82, PSB Rc18, PR41543-B-14-2-1-2, and IR42 ranged from 2.40 to 2.83g/plant and were similar to the belowground biomass of FR13A. NSIC Rc194 had the lowest belowground biomass and was similar to the belowground biomass of Ciherang Ag+ Sub1.

B. 50cm Floodwater depth from 21 to 35 days after transplanting

- One day before flooding, plant heights of the 7 rice genotypes ranged from 49.5 to 78.5cm (Table 30). Plant heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 59.0 cm and 48.1 cm, respectively, and 49.5cm for the susceptible check IR42. One week after flooding (28 DAT), plant heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 80.9cm and 68.7cm, respectively. Plant heights of NSIC Rc194, PR41543-B-14-2-1-2 PSB Rc18, PSB Rc82 and IR42 ranged from 71.4cm to 78.3cm and were similar to plant height of Ciherang Ag+ Sub1 and FR13A. Two weeks after flooding (35 DAT), plants heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 89.0 cm and 67.6cm, respectively. Plant heights of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, and IR42 ranged from 83.9cm to 86.5cm and were similar to the plant height of FR13A. Plant height of PSB Rc82 was highest at 95.7cm.

- Three weeks after de-flooding (56 DAT), plants heights of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 93.8cm and 70.5cm, respectively. Plant heights of PSB Rc18 and IR42 ranged from 91.5 cm and 97.5 cm and were similar to plant height of FR13A. Plant heights of NSIC Rc194 and PR41543-B-14-2-1-2 and Ciherang Ag+ Sub1 ranged from 70.5 cm to 90.9cm and were significantly lower than the plant height of FR13A (Table 30).

- One day before flooding, tiller numbers of the 7 rice genotypes ranged from 12 to 24 tillers/plant (Table 30). Tiller numbers were 17 tillers/plant for the tolerant checks FR13A and 12 tillers/plant for the susceptible check IR42. One week after flooding (28 DAT), tiller numbers for the tolerant checks FR13A and Ciherang Ag+ Sub1 were 18 tillers/plant and 13 tillers/plant, respectively. Tiller numbers for NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, and IR42 ranged from 12 to 20 tillers/plant and were similar to tiller numbers of FR13A and Ciherang Ag+ Sub1. Two weeks after flooding (35 DAT), tiller numbers for the tolerant checks FR13A and Ciherang Ag+ Sub1 were 13 tillers/plant and 8 tillers/plant, respectively. Tiller numbers for NSIC Rc194, PR41543-B-14-2-1-2, and PSB Rc18 ranged from 9 to 11 tillers/plant and were similar to tiller number of the tolerant Ciherang Ag+ Sub1, but significantly lower than the tiller number of FR13A. Susceptible check IR42 had the highest tiller number.

- Three weeks after de-flooding (56 DAT), tiller numbers of the tolerant checks FR13A and Ciherang Ag+ Sub1 ranged from 22 to 24 tillers/plant and were similar to tiller numbers of NSIC Rc194, PR41543-B-14-2-1-2,PSB Rc18, PSB Rc82, and IR42.

- One week after flooding (28 DAT), shoot elongation rates of the tolerant checks FR13A and Ciherang Ag+Sub1 were 0.63/day and 0.59cm/day , respectively (Table 31). Shoot elongation rates of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, PSB Rc82 and IR42 ranged from 0.46 to 0.92cm/day. PR41543-B-14-2-1-2 had the lowest shoot elongation of 0.46cm/day. Two weeks after flooding (35 DAT), shoot elongation rates of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 0.99 cm/day and 0.64 cm/day, respectively. Shoot elongation rates of NSIC Rc194, PSB Rc18, PSB Rc82, PR41543-B-14-2-1-2, and IR42 ranged from 0.64 to 1.31 cm/day. Ciherang Ag+ Sub1 had the lowest shoot elongation rate of 0.64 cm/day.

- Three weeks after de-flooding (56 DAT), shoot elongation rates of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 0.95cm/day and 0.64cm/day, respectively. Shoot elongation rates of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, PSB Rc82, and IR42 ranged from 0.76 to 1.27 cm/day. Ciherang Ag+ Sub1 had the lowest shoot elongation rate of 0.67cm/day.

- One day before flooding, aboveground biomass of the 7 rice genotypes ranged from 5.0 to 6.5g/plant (Table 32). Aboveground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 5.8 g/plant and 5.7 g/plant, respectively. Aboveground biomass of NSIC Rc194, PR41543-B-14-2-1-2, PSB Rc18, PSB Rc82, and IR42 ranged from 5.0 to 56.5g/plant and were similar to the aboveground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1. Belowground biomass of the 7 rice genotypes ranged from 0.17 to 0.43g/plant (Table 6). Belowground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 0.27 g/plant and 0.30g/plant, respectively. Belowground biomasses of NSIC Rc194, PSB Rc18, PSB Rc82, PR41543-B-14-2-1-2, and IR42 ranged from 0.17 to 0.43g/plant and were similar to the belowground biomasses of the tolerant checks.

- Three weeks after de-flooding (56 DAT), aboveground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 28.9g/plant and 20.5 g/plant, respectively. Aboveground biomasses of NSIC Rc194,PSB Rc82, PR41543-B-14-2-1-2, and IR42 ranged from 23.2 to 32.3

g/plant and were similar to the aboveground biomass of FR13A. Belowground biomasses of the tolerant checks FR13A and Ciherang Ag+ Sub1 were 4.9g/plant and 2.2g/plant, respectively. Belowground biomasses of NSIC Rc 194, PSB Rc82, PSB Rc18, PR41543-B-14-2-1-2, and IR42 ranged from 1.6 to 2.9g/plant and were similar to the belowground biomass of Ciherang Ag+ Sub1, but lower than the belowground biomass of FR13A.

Field

A. 30 cm floodwater depth from 21 to 35 days after transplanting, and grain yield

21-day old seedlings

- Grain yields of the tolerant check Ciherang Ag+Sub1 ranged from 5.5 to 6.8 t ha-1 and were higher than yields of the popular inbred PSB Rc82 and PR41543-B-14-2-1-2 with no post-flood N application, and post-flood N applications at 2 and 7 days after deflooding (Table 33).

44-day old seedlings

- Grain yields of the tolerant check Ciherang Ag+Sub1 and PSB Rc82 ranged from 5.2 to 6.7 t ha-1a and were higher than yields of PR41543-B-14-2-1-2 with no post-flood N application, and post-flood N applications at 2 and 7 days after deflooding (Table 33).

- Trends indicated that yields with post-flood N application at 7 days after deflooding were higher than yields with post-flood N application at 2 days after deflooding, regardless of seedling age (Table 33).

B. 50cm floodwater depth from 21 to 35 days after transplanting, and grain yield

21-day old seedlings

- Grain yields of the tolerant check Ciherang Ag+Sub1 and the popular inbred PSB Rc82 ranged from 3.2 to 4.2 t ha-1 and were higher than yields of PR41543-B-14-2-1-2 with no post-flood N application, post-flood N applications at 2 and 7 days after deflooding (Table 34).

44-day old seedlings

- Grain yields of PSB Rc82 ranged 3.1 to 4.0 t ha-1 and were higher than yields of the tolerant check Ciherang Ag+ Sub1 and PR41543-B-14-2-1-2 with no post-flood N application and post-flood N applications at 2 days after deflooding. Yields of PSB Rc82 and Ciherang Ag+Sub1 did not differ and were highest at about 4.0t ha-1 with post-flood N application at 7 days after deflooding (Table 34).

- Overall, for the 3 genotypes and 3 nitrogen fertilizer treatments, yields with 30 cm floodwater depth, *i.e.*, 2.1 to 6.8 t ha-1, were higher than yields with 50 cm floodwater depth, i.e., 1.7 to 4.2t ha-1 (Tables 33 and 34). Across treatments, 21-day old seedlings tend to have higher yields than 44-day old seedlings especially for the tolerant check Ciherang Ag+ Sub1.

Table 27. Plant height and tiller number/plant of 4 rice genotypes, 2 tolerant checks FR13A and Ciherang Ag+ Sub1, and 1 susceptible check IR42 before, during and after exposure to short-term flooding (2 weeks with a floodwater depth of 30 cm from 21 to 35 days after transplanting). PhilRice CES Screenhouse, 2016.

Days After Transplanting (DAT)	Genotype	Plant Height/Plant (cm)	Tiller Number/ Plant
21 DAT (One day before Flooding)	FR13A	78.50 a	5 ab
	Ciherang Ag+ Sub1	50.0 cd	4 c
	IR42	50.17 cd	4 bc
	NSIC Rc194	47.17 d	5 abc
	PR41543-B-14-2-1-2	49.83 cd	6 a
	PSB Rc18	70.17 b	5 ab
	PSB Rc82	54.50 c	5 ab
28 DAT (1 week after Flooding)	FR13A	88.17 a	5 bc
	Ciherang Ag+ Sub1	61.33 c	6 ab
	IR42	63.33 c	6 ab
	NSIC Rc194	64.17 c	6 ab
	PR41543-B-14-2-1-2	63.00 c	6 ab
	PSB Rc18	63.17 c	6 a
	PSB Rc82	71.33 b	4 c
35 DAT (2 weeks after Flooding)	FR13A	116.33 a	6 ab
	Ciherang Ag+ Sub1	75.00 d	5 b
	IR42	70.17 e	6 ab
	NSIC Rc194	69.17 e	6 ab
	PR41543-B-14-2-1-2	71.83 e	5 ab
	PSB Rc18	89.00 b	6 a
	PSB Rc82	79.67 c	4 b
56 DAT (3 weeks after de-flooding)	FR13A	134 a	5 a
	Ciherang Ag+ Sub1	88.67 ab	3 a
	IR42	60.67 b	4 a
	NSIC Rc194	88.90 ab	4 a
	PR41543-B-14-2-1-2	90.67 ab	5 a
	PSB Rc18	108.33 ab	5 a
	PSB Rc82	94.33 ab	5 a

Means followed by the same letter in a column were significantly different at 5 % level of significance using Tukey's Honest Significant Difference (HSD) Test.

Table 28. Shoot elongation rates of 4 rice genotypes, 2 tolerant checks FR13A and Ciherang Ag+ Sub1, and 1 susceptible check IR42 after short-term partial flooding (STPF) with 30cm floodwater depth from 21 and 35 days after transplanting (DAT), and 3 weeks after de-flooding at 56 DAT. PhilRice Screenhouse, 2016.

Genotype	Shoot Elongation Rate (cm/day)		
	1 week after flooding (28 DAT)	2 weeks after flooding (35 DAT)	3 weeks after de-flooding (56 DAT)
FR13A	0.28	1.08	1.59
Ciherang Ag+ Sub1	0.32	0.71	1.10
IR42	0.38	0.57	0.30
NSIC Rc194	0.49	0.63	1.19
PR41543-B-14-2-1-2	0.38	0.63	1.16
PSB Rc18	0.25	0.99	1.54
PSB Rc82	0.38	0.63	1.16

Table 29. Biomass accumulation or dry matter yields of 4 rice genotypes and 2 tolerant checks FR13A and Ciherang Ag+ Sub1, and 1 susceptible check IR42 before flooding at 21 days after transplanting (DAT) and 3 weeks after de-flooding at 56 DAT. PhilRice Screenhouse, 2016.

Days After Transplanting (DAT)	Genotypes	Aboveground Biomass (g/plant)	Belowground Biomass (g/plant)
21 DAT (Before Flooding)	FR13A	1.63 a	0.17 a
	Ciherang Ag+ Sub1	1.67 a	0.20 a
	IR42	1.97 a	0.23 a
	NSIC Rc194	3.07 a	0.40 a
	PR41543-B-14-2-1-2	2.60 a	0.53 a
	PSB Rc18	3.77 a	0.20 a
	PSB Rc82	1.60 a	0.27 a
56 DAT (After de-flooding)	FR13A	23.93 a	3.87 a
	Ciherang Ag+ Sub1	12.23 ab	2.03 b
	IR42	11.77 ab	2.40 ab
	NSIC Rc194	11.37 b	2.00 b
	PR41543-B-14-2-1-2	11.83 ab	2.50 ab
	PSB Rc18	18.13 ab	2.83 ab
	PSB Rc82	10.70 b	2.40 ab

Means followed by the same letter in a column were significantly different at 5 % level of significance using Tukey's Honest Significant Difference (HSD) Test.

Table 30. Plant height and tiller number/plant of 4 rice genotypes, 2 tolerant checks FR13A and Ciherang Ag+ Sub1, and 1 susceptible check IR42 before, during and after exposure to short-term flooding i.e., 2 weeks with a floodwater depth of 50 cm from 21 to 35 days after transplanting.. PhilRice Screenhouse, 2016.

Days After Transplanting (DAT)	Genotype	Plant height/plant (cm)	Tiller number/plant
21 DAT (One day before Flooding)	FR13A	59. 00a	17ab
	Ciherang Ag+ Sub1	48.13ab	12b
	IR42	49.53ab	16ab
	NSIC Rc194	47.33ab	16b
	PR41543-B-14-2-1-2	55.4ab	12b
	PSB Rc18	44.87b	24
	PSB Rc82	53.97ab	13b
28 DAT (1 week after Flooding)	FR13A	80.97a	18a
	Ciherang Ag+ Sub1	68.73b	13a
	IR42	74.9ab	20a
	NSIC Rc194	72.43ab	14a
	PR41543-B-14-2-1-2	71.4ab	12a
	PSB Rc18	77.03ab	19a
	PSB Rc82	78.27ab	13a
35 DAT (2 weeks after Flooding)	FR13A	89.03ab	13ab
	Ciherang Ag+ Sub1	67.6c	8c
	IR42	86.53ab	15a
	NSIC Rc194	86.5ab	9c
	PR41543-B-14-2-1-2	83.93b	9c
	PSB Rc18	86.2ab	11bc
	PSB Rc82	95.7a	10bc
56 DAT (3 weeks after de-flooding)	FR13A	93.8a	24a
	Ciherang Ag+ Sub1	70.47c	22a
	IR42	91.5a	20a
	NSIC Rc194	90.97b	21a
	PR41543-B-14-2-1-2	82.4b	22a
	PSB Rc18	90.8ab	24a
	PSB Rc82	97.5a	24a

Means followed by the same letter in a column were significantly different at 5 % level of significance using Tukey's Honest Significant Difference (HSD) Test

Table 31. Shoot elongation rates of 4 rice genotypes and 2 tolerant checks FR13A and Ciherang Ag+ Sub1, and 1 susceptible check IR42 after short-term partial flooding (STPF) with 50cm floodwater depth from 21 and 35 days after transplanting (DAT) and 3 weeks after de-flooding at 56 DAT. PhilRice Screenhouse, 2016.

Genotype	Shoot Elongation Rate (cm/day)		
	1 weeks after flooding (28 DAT)	2 weeks after flooding (35 DAT)	3 weeks afterde-flooding (56 DAT)
FR13A	0.63	0.99	0.95
Ciherang Ag+ Sub1	0.59	0.64	0.67
IR42	0.72	1.20	1.18
NSIC Rc194	0.72	1.25	1.30
PR41543-B-14-2-1-2	0.46	0.77	0.76
PSB Rc18	0.92	1.31	1.27
PSB Rc82	0.69	1.24	1.17

Table 32. Biomass accumulation of 4 rice genotypes and 2 tolerant checks FR13A and Ciherang Ag+ Sub1, and 1 susceptible check IR42 before flooding at 21 days after transplanting (DAT) and 3 weeks after de-flooding at 56 DAT. PhilRice Screenhouse, 2016.

Days After Transplanting (DAT)	Genotype	Aboveground Biomass (g/plant)	Belowground Biomass (g/plant)
21 DAT (one day before flooding)	FR13A	5.8a	0.266a
	Ciherang Ag+ Sub1	5.7a	0.3a
	IR42	5.37a	0.166a
	NSIC Rc194	5a	0.333a
	PR41543-B-14-2-1-2	6.2a	0.4a
	PSB Rc18	6.17a	0.366a
	PSB Rc82	6.53a	0.433a
56 DAT (3 weeks fter de-flooding)	FR13A	28.99ab	4.92a
	Ciherang Ag+ Sub1	20.53b	2.15b
	IR42	23.19ab	2.44b
	NSIC Rc194	26.99ab	2.37b
	PR41543-B-14-2-1-2	32.28a	2.67ab
	PSB Rc18	20.99b	1.55b
	PSB Rc82	23.08ab	2.87ab

Means followed by the same letter in a column were significantly different at 5 % level of significance using Tukey's Honest Significant Difference (HSD) Test.

Table 33. Grain yields of 2 rice genotypes and 1 tolerant check Ciherang Ag+ Sub1 after short-term partial flooding (SPTF) *i.e.*, 2 weeks with a floodwater depth of 30 cm from 21 to 35 days after transplanting (DAT). F1= without urea N fertilizer. F2= N application 2 days after de-flooding. F3= N application 7 days after de-flooding. S1= 21 day old seedling. S2= 44 day old seedling. Mean + standard error. Note: FR13A samples are being processed. PhilRice field experiment WS 2016.

Treatment	Grain Yield (t/ha)		
	PSB Rc82	Ciherang Ag+ Sub1	PR41543-B-14-2-1-2
F1(S1)	6.2 ± 0.6	6.8 ± 0.9	3.3 ± 0.5
F2(S1)	4.6 ± 0.4	5.5 ± 0.6	2.8 ± 0.2
F3(S1)	4.9 ± 0.5	6.2 ± 0.3	4.6 ± 0.6
F1(S2)	5.6 ± 0.9	6.5 ± 0.3	4.2 ± 0.8
F2(S2)	5.2 ± 0.6	5.2 ± 0.5	2.1 ± 1.2
F3(S2)	6.7 ± 0.9	5.7 ± 0.3	4.6 ± 0.8

Table 34. Grain yields of 2 rice genotypes and 1 tolerant check Ciherang Ag+ Sub1 after short-term partial flooding (SPTF) *i.e.*, 2 weeks with a floodwater depth of 50 cm from 21 to 35 days after transplanting (DAT). F1= without urea N fertilizer. F2= N application 2 days after de-flooding. F3= N application 7 days after de-flooding. S1= 21 day old seedling. S2= 44 day old seedling. Mean + standard error. Note: FR13A samples are being processed. PhilRice field experiment WS 2016.

Treatment	Grain Yield (t/ha)		
	PSB Rc82	Ciherang Ag+ Sub1	PR41543-B-14-2-1-2
F1(S1)	3.4 ± 0.2	3.7 ± 1.1	2.4 ± 0.6
F2(S1)	3.2 ± 1.6	4.2 ± 1.0	2.3 ± .8
F3 (S1)	3.3 ± 0.4	4.0 ± 0.2	2.7 ± 0.4
F1(S2)	3.1 ± 0.2	1.6 ± 0.9	2.8 ± 1.6
F2(S2)	4.0 ± 0.2	2.4 ± 0.5	2.0 ± 0.5
F3(S2)	4.0 ± 0.3	3.8 ± 0.2	2.5 ± 0.8

VI. Soil Health, Water Quality and Availability

Project Leader: Evelyn F. Javier

The project aimed to develop technologies that will improve and sustain soil health, quality and productivity, and water quality and conservation. Studies can include: assessment and evaluation of depositions of light and heavy metals due to mining and mine tailings in the irrigated rice ecosystem and assessment of the effect of rice farming practices on the possible heavy metals accumulation in rice plants. It will also include evaluation of water quality in irrigation systems and assessment on its effect on rice production. Water management technologies are deemed necessary to increase water productivity, increased area irrigated, and efficient water utilization in rice production.

Short term and long-term assessment of heavy metals deposition in the paddy soils of Regions 1 and 3

EFJavier, PSRamos,Jr, and AEESpiritu

Heavy metals contamination is one of the crucial environmental problem due to human activities. Leaking of mine tailing (waste pond) from mining companies may cause deposition of heavy metals in rice paddy soils through the delivery system of the irrigation canal or rivers. Rice plants that are growing in heavy metal-polluted soils show altered metabolism, growth reduction, lower biomass production, and bioaccumulation. The main concern now is the build-up of sediments from Sa Roque Dam (SRD) and irrigates the upstream, midstream, downstream, and lower Agno River Irrigation System (ARIS). Likewise, concerns on the risks of contamination and bioaccumulation of heavy metals in the areas being served by the San Roque Dam. Hence, this project was conceptualized to determine the extent, levels, build- up and long-term effects of heavy metal contamination in the paddy rice soils and rice grain particularly in areas being served by the Agno River.

Activities:

1. Collection of samples (soils, rice straw, and grains) from the rice areas near or along the different irrigation laterals in reference to the main canals of San Roque Dam (SRD) and Agno River:
   - Seven (7) laterals were pegged in the upstream Agno River Irrigation System (UARIS) of SRD main canal;
   - Five (5) in the midstream Agno River Irrigation System (MARIS) of the SRD main canal;
   - Six (6) in the dowstream Agno River Irrigation System (DARIS) of the SRD main canal;

   - Five (5) in the lower Agno River Irrigation System (LARIS) of the SRD main canal; and
   - Two (2) sites along irrigation canal not serviced by irrigation system connected to the SRD main stream.
2. Characterization of farming practices of those tagged sites: their cropping sequence, fertilizer application level, pesticide application level, and the extent of mechanization.
3. Gathering data/information from the affected farmers along these pegged areas for baseline information and their perceptions on the extent of the effect of the leak of mine tailings.

Results:

- Farmers from sampling sites already observed deposition of sandy-like white to gray materials. The soil was difficult to plow, the irrigation water is milky-like, plant rice has stunted growth, fewer tillers, and reduced yield. To counteract these observations, they applied more fertilizers and flooding their rice paddy field continuously. To minimize the entering of sediments, the farmers made some excavation to serve as the impounding and filtering pond and they collected the sediments to avoid the accumulation of the sediments in their paddy rice fields.
- In 2015 WS and 2016 DS, bioaccumulation of light metals (Zn, Cu, Fe, and Mn) in rice straw was higher than rice grain although bioaccumulation of the light metals in rice grain were lower than the maximum allowable limit of light metals in plant set by WHO/ FAO (Table 35).
- In 2016 DS, soil copper (Cu) concentration in UARIS, MARIS, DARIS and LARIS were relatively low and not exceeding the maximum permissible levels in soil set by WHO/FAO. But soil Cu during 2016 WS were greater than the maximum permissible levels in soil set by WHO/FAO in UARIS, MARIS, and DARIS except DARIS (Table 36).
- In 2015 WS and 2016 DS, soil zinc, iron, and manganese concentration of sampling sites in UARIS, MARIS, DARIS, and LARIS were relatively low and not exceeding the maximum permissible levels in soil set by WHO/FAO.

- Concentration of heavy metals (cadmium, arsenic, mercury, and lead) in soils, grain and straw were not analyzed for 5 seasons now, because of 2 failed biddings of requested outsourced HM analyses while the light metals (Zn, Cu, Fe, and Mn) content of same samples were analyzed in the ASPPD Analytical Laboratory.

Table 35. Light metals values of grain, straw, and total plant from upstream ARIS, midstream ARIS, downstream ARIS, and lower ARIS compare to worldwide normal light metal content of rice grain and maximum allowable limit of light metals in plant (WS 2015 and DS 2016).

Groups of Location (relative the SRD position)	*Zn*	*Cu*	*Fe*	*Mn*
	(ppm)			
2015 Wet Season				
Upstream ARIS sites (n=7)	6.32	116.43	232.90	10.14
Midstream ARIS sites (n=5)	8.01	125.74	208.93	27.21
Downstream ARIS sites (n=6)	6.03	106.26	213.90	33.40
Lowerstream ARIS sites (n=5)	1.06	9.63	155.03	50.45
2016 Dry season				
Upstream ARIS sites (n=7)	7.07	91.60	135.33	19.80
Midstream ARIS sites (n=5)	5.73	95.10	168.31	22.40
Downstream ARIS sites (n=6)	3.50	79.58	113.43	39.20
Lowerstream ARIS sites (n=5)	3.09	10.53	62.23	13.61
Worldwide normal surface soils[a]	*45-100*	*13-24*	*5,000-50,000*	*437*
Maximum permissible levels in soil (WHO/FAO)[b]	*300*	*100*	*50,000*	*2,000*

[a]Kabata-Pendias (2001); and bWHO/FAO cited by Chiroma et al. (2014); cdDobermann and Fairhurst (2000) ppm= parts per million

Table 36. Light metals values of soils from upstream ARIS, midstream ARIS, downstream ARIS, and lower ARIS compare to worldwide normal surface soilsa, and maximum permissible levels in soilb (WS 2015 and DS 2016).

Groups of Location (relative the SRD position)	*Zn*			*Cu*			*Fe*			*Mn*		
	ppm (2015 Wet season)											
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Upstream ARIS sites (n=**7**)	16.00	23.79	39.79	4.03	4.79	8.82	38.55	295.95	334.49	27.01	275.27	302.28
Midstream ARIS sites (n=**5**)	15.05	36.86	51.91	3.09	15.45	18.54	27.75	368.93	396.67	34.61	412.95	447.56
Downstream ARIS sites (n=**6**)	14.71	33.82	48.54	3.97	6.48	10.45	37.70	253.70	291.40	36.96	421.54	458.50
Lowerstream ARIS sites (n=5-1=**4**)*	12.00	16.17	28.16	6.22	2.72	8.94	32.97	273.38	306.35	26.85	402.13	428.98
Groups of Location (relative the SRD position)	*Zn*			*Cu*			*Fe*			*Mn*		
	ppm (2016 Dry season)											
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Upstream ARIS sites (n=**7**)	13.81	16.87	30.68	3.84	4.79	8.62	42.88	152.45	195.32	39.58	283.36	322.93
Midstream ARIS sites (n=**5**)	12.24	15.85	33.23	4.44	4.20	10.19	58.45	72.00	165.98	36.37	255.68	411.86
Downstream ARIS sites (n=**6**)	13.93	26.03	39.96	3.50	18.25	21.75	57.91	220.05	277.96	61.26	446.25	507.51
Lowerstream ARIS sites (n=5-4=**1**)#	13.43	11.86	25.29	4.03	4.38	8.40	49.83	94.13	143.95	46.30	267.63	313.93
Worldwide normal light metal content of rice grain[a]	*21*			*2.8*			*1.4 - 10*			*48*		
Maximum allowable limit of light metals in plant[b]	*100*			*73*			*425*			*500*		
Critical levels for rice plant toxicity[c]	*<20*			*<6*			*<100-150*			*0.10-0.15*		
Critical levels for rice plant deficiecy[d]	–			–			*>300-500*			*>800-2500*		
**out of 5 sites, 1 site is affected by typhoon while 4 sites are unaffected*												
#out of 5 sites, 1 site is rice-rice cropping while 4 sites is rice-corn cropping system												

[a]Kabata-Pendias (2001); and bWHO/FAO cited by Chiroma et al. (2014); cdDobermann and Fairhurst (2000) ppm- part per million

VIII. Nutrient and Pest Interactions

Project Leader: Jehru C. Magahud

This project aimed to identify and propagate approaches for integrating management of principal insect pests and diseases with compatible nutrient and crop management. One important component output is on profiling nutrient and pest interaction and management wherein basic studies will be conducted by ASPPD and CPD to develop appropriate crop management to minimize yield loss due to pests (and diseases).

Relationship of nitrogen to occurrence of rice diseases, and the role of nitrogen-fixing microorganism

JC Magahud, JA Cruz, JP Rillon, SLP Dalumpines and ND Santiago

High rates of nitrogen (N) fertilizer are applied to achieve high yields, and this application promote luxuriant vegetative growth with dense foliar canopies. However, this type of canopy structure provides favorable environment for rice diseases. Rice diseases can result in yield losses of up to 75%. Meanwhile, researchers have recently reported that nitrogen-fixing bacteria can be used as plant growth-promoter and as biocontrol agent. They can affect plant growth through reduction or prevention of deleterious effects of phytopathogenic organisms. They produce inhibitory substances such as siderophore and antibiotics, and increase natural resistance of plants.

The study aims to determine the relationship of N to occurrence of rice diseases, and determine the relationship of N2-fixing microorganism to rice disease. A screenhouse experiment was conducted with three factors: 1) N level, 2) inoculation or non-inoculation of rice diseases, and 3) inoculation or non-inoculation of N2-fixing microorganims. Rice diseases are bacterial leaf blight (BLB) and sheath blight (ShB). Diseases were inoculated into leaves or tillers, while N2-fixing microorganims were inoculated into the soil 1-2 cm from the base of plants.

Activities:

- Determining nutrient status of soil medium by conducting minus-one element technique (MOET).
- Assessing rice yields and incidence of diseases in different levels of N by conducting artificial inoculation of diseases and applying different amounts of N fertilizer in potted rice plants.
- Assessing effects of N2-fixing microorganisms to rice disease by conducting artificial inoculation of microorganism in the roots of potted rice plants

Results:

- Soil medium was collected from a rice farm in Maligaya, Science City of Muñoz, Nueva Ecija (15°40’36.35”N, 120°52’59.39”E). Application rate of chemical fertilizers in the farm is 100-29-29kg NPK per hectare for dry season, and 71-48-23 kg for wet season. The soil is not applied with organic fertilizers, and the farmer practices burning of rice straw.

- The soil was selected because it is strongly deficient in N. Using MOET in 2015 wet and 2016 dry seasons, it was found that this soil is deficient in nitrogen, potassium, and sulfur; and sufficient in phosphorus, copper, and zinc (Tables 37a and 37b). Hence, specific amount of potassium sulfate and potassium chloride was applied to potted rice plants at early and panicle initiation stages. This is to supply the need for all deficient nutrients except N.

- Grain yields among rice plants, ShB-inoculated or not, were significantly highest at 190 to 221kg N ha-1 in DS, and 158 to 221kg N ha-1 in WS (Figure 22). Yield was lower in ShB-inoculated plants in WS. Least ShB severity was observed at 0 and 31 kg N ha-1, 0% in DS and 27-29% in WS (Figure 23), due to less succulent plant tissues that limits spread of disease.

- Grain yields among rice plants, BLB inoculated or not, were significantly highest at 190 to 221 kg N ha-1 in DS, and at 158 to 221 kg N ha-1 in WS (Figure 24). Yield was lower in BLB-inoculated plants during DS. Least BLB severity of 20 to 25% was observed at 0 and 31kg N ha-1 in DS, and 20% at 0kg N ha-1 in WS (Figure 25) due to limited source of nutrients for pathogen.

- Fertilizer application rates that give optimum growth and grain yield under screenhouse condition are 190kg N ha-1 in DS, and 158kg N ha-1 in WS. These rates also result in insignificant yield damage from ShB and BLB. There is a need to verify the results in field condition.

- At zero fertilizer treatment, plants inoculated with N2-fixing bacteria had lower BLB severity at 14 days after inoculation compared to uninoculated treatment. Similarly, there was a decreasing trend of BLB incidence up to 158kg N ha-1 (Figure 26).

Table 37a. Nutrient deficiency (D) and sufficiency (S) based on the percent biomass of rice grown in omission pots relative to the biomass planted in pot supplied with complete set of nutrients.+

Site		Omission Pots					
	Complete	-Nitrogen	-Phosphorus	-Potassium	-Sulfur	-Copper	-Zinc
	g	% biomass relative to the complete treatment					
2015 WS	39.0	12.2 D	92.2 S	50.7 D	49.9 D	85.5 S	102.1 S
2016 DS	34.1	16.4 D	70.5 D	43.1 D	68.8 D	115.1 S	109.9 S

Table 37b. Nutrient deficiency (D) and sufficiency (S) based on the percent tiller count of rice grown in omission pots relative to the tiller count planted in pot supplied with complete set of nutrients.+

Site		Omission Pots					
	Complete	-Nitrogen	-Phosphorus	-Potassium	-Sulfur	-Copper	-Zinc
	g	% tiller count relative to the complete treatment					
2015 WS	38	18.4 D	110.5 S	47.4 D	52.6 D	76.3 D	100.0 S
2016 DS	49	26.5 D	87.8 S	63.3 D	79.6 S	120.4 S	130.6 S

+deficient (D) if tiller count is <80%, and sufficient (S) if >80% of the tillers planted in the pot supplied with complete set of nutrients

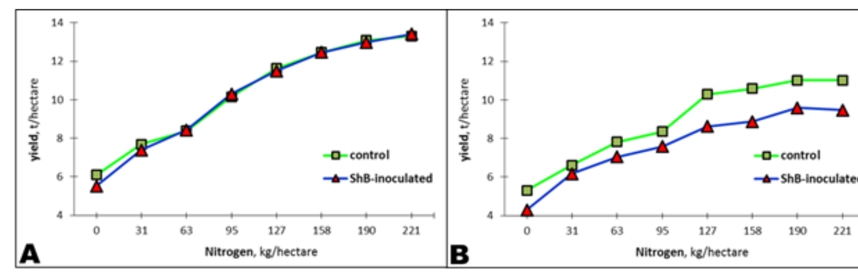

Figure 22. Grain yield of control and ShB-inoculated rice for 2016 DS (A) and WS (B).

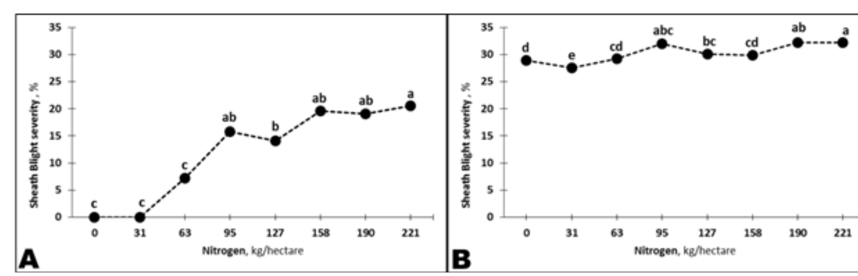

Figure 24. Grain yield of control and BLB-inoculated rice for 2016 DS (A) and WS (B).

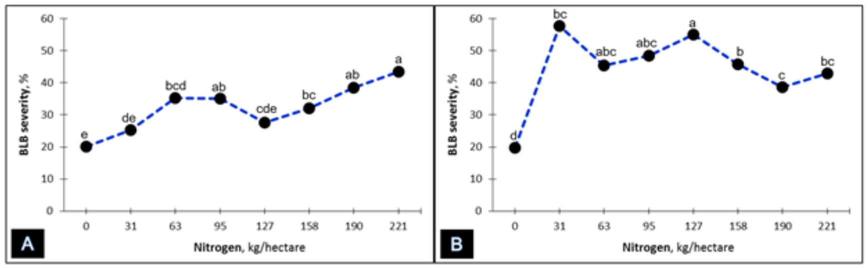

Figure 25. Bacterial leaf blight severity for 2016 DS (A) and WS (B).

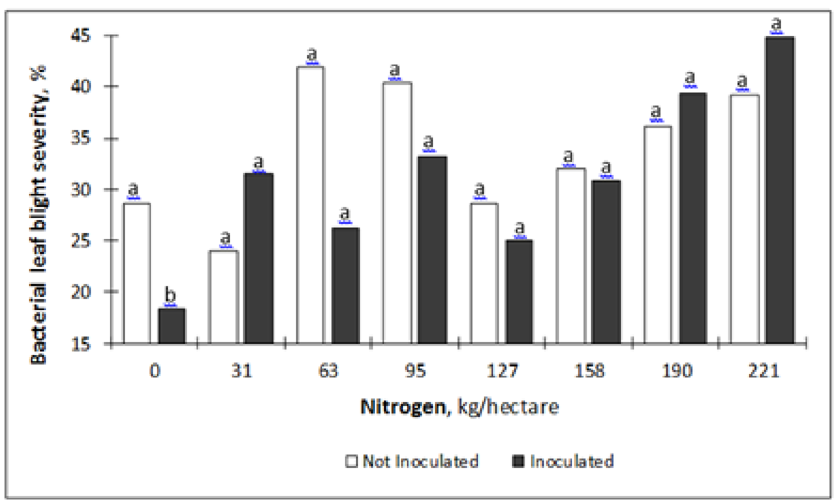

Figure 26. Comparison for percentage of bacterial leaf blight severity (median) of rice uninoculated (UI) vs. inoculated (I) with N2-fixing bacteria for 2016 DS.

VII. ASPPD Research and Analytical Laboratory Systems and Maintenance

Project Leader: Annie E. Espiritu

To support the ASPPD R&D activities and capacitate the laboratory system for quality data and analyses, the Research and Analytical Laboratory Systems and Maintenance Project of ASPPD was proposed and funded in 2012DS. The current ASPPD laboratories and greenhouse facilities needs some improvements and equipment updating as well as preventive maintenance services and calibration (in conformance to the ISSO certification of PhilRice). Normally, laboratory management and maintenance to complement and implement the IMS policy of the Institute had been sourcing out funds from external sources. The external sources though of higher fund support are not stable. Hence, this project was established to (1) provide assistance in the improvement/upgrade of the laboratory facilities for better quality research output; (2) constantly optimize laboratory/ chemical procedures for soils and plant samples; and (3) build-up database and inventory of information on the chemical and laboratory supplies and usages.

Activities:

- Chemical and laboratory supplies inventory and purchase.
- Annual equipment preventive maintenance service and calibration.
- Data-based management system.
- Consultation, technical networking and inter-laboratory collaboration.

Results:

- Database on the inventory of incoming and outgoing of chemicals which prevented the over-supply of chemicals was maintained and updated.
- Twenty eight laboratory equipment had undergone annual preventive maintenance service (PMS) and calibration while 11 equipment were repaired.
- The 2016 semi-annual report on the requirement of "Permit to Purchase" and "Controlled Precursors and Essential Chemicals" on the procurement and usage of chemical supplies in our research activities controlled by the Philippine Drug Enforcement Agency (PDEA) was submitted.

- List of equipment for upgrading, and replacement of unserviceable equipment was prepared and submitted
- The use of ASPPD laboratory facility was provided to several centers/divisions (CCC, ISD, RCFS, REMD,IRBAS, KOPIA, ABCRE, PBBD)
- Walk-in visitors/guests from various universities/sectors were accommodated for technical assistance, laboratory orientation and for laboratory benchmarking.
- Technical assistance and On-the-Job Training were provided to students.
- Seminar on “Best Practices and Challenges Toward Sustainability in Laboratory Management” was attended for equipping of staff.

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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Department of Agriculture
Philippine Rice Research Institute

PhilRice Central Experiment Station; Maligaya, Science City of Muñoz, 3119 Nueva Ecija
Tel: (44) 456-0277 • Direct line/Telefax: (44) 456-0112 • Email: prri.mail@philrice.gov.ph
PhilRice Text Center: 0920-911-1398 • Websites: www.philrice.gov.ph; www.pinoyrice.com

BRANCH STATIONS:

PhilRice Agusan, Basilisa, RTRomualdez, 8611 Agusan del Norte;
Telefax: (85) 343-0768; Tel: 343-0534; 343-0778; Email: agusan.station@philrice.gov.ph
PhilRice Batac, MMSU Campus, Batac City, 2906 Ilocos Norte;
Telefax: (77) 772- 0654; 670-1867; Tel: 667-1508; Email: batac.station@philrice.gov.ph
PhilRice Bicol, Batang, Ligao City, 4504 Albay; Tel: (52) 284-4860; Mobile: 0918-946-7439 ;
Email: bicol.station@philrice.gov.ph
PhilRice Isabela, Malasin, San Mateo, 3318 Isabela; Mobile: 0908-895-7796; 0915-765-2105;
Email: isabela.station@philrice.gov.ph
PhilRice Los Baños, UPLB Campus, Los Baños, 4030 Laguna; Tel: (49) 536-8620; 501-1917;
Mobile: 0920-911-1420; Email: losbanos@philrice.gov.ph
PhilRice Midsayap, Bual Norte, Midsayap, 9410 North Cotabato;
Tel: (64) 229-8178; 229-7241 to 43; Email: midsayap.station@philrice.gov.ph
PhilRice Negros, Cansilayan, Murcia, 6129 Negros Occidental;
Mobile: 0932-850-1531; 0915-349-0142; Email: negros.station@philrice.gov.ph
PhilRice Field Office, CMU Campus, Maramag, 8714 Bukidnon;
Mobile: 0916-367-6086; 0909-822-9813
Liaison Office, 3rd Floor, ATI Bldg, Elliptical Road, Diliman, Quezon City; Tel: (02) 920-5129

SATELLITE STATIONS:

Mindoro Satellite Station, Alacaak, Sta. Cruz, 5105 Occidental Mindoro; Mobile: 0908-104-0855
Samar Satellite Station, UEP Campus, Catarman, 6400 Northern Samar; Mobile: 0948-800-5284